The comprehension of doubly quantified sentences.

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I declare that the work in this thesis is all my own and has not been submitted for any other degree.

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Abstract.

The comprehension of doubly quantified sentences.

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The factors influencing the comprehension of doubly quantified sentences were examined in a series of experiments which included drawing tasks, evaluation tasks, and reading tasks.

It was found that the inherent characteristics of individual quantifiers affected scope assignment. An effect of word order was also noted with all experimental tasks but this was not constant. Limited support was found for the view that the grammatical function of the universal quantifier, which is revealed as an interaction between order and voice, affects the interpretation of doubly quantified sentences.

Results from the final set of experiments, which include both evaluation and reading tasks, suggest that scope is not fully disambiguated during reading a doubly quantified sentence, but that scope is assigned only if this is made necessary by subsequent tasks. Results are discussed in terms of the theory of Mental Models.

The role of context and pragmatic factors on scoping decisions is discussed. Johnson-Laird, Byrne and Tabossi's (1989) model of reasoning with quantifiers is considered. Some tentative proposals to account for the processing of doubly quantified sentences are put forward on the basis of results indicated in the Thesis. These proposals discuss the influence of syntax and semantics on the comprehension of experimental sentences. Finally, suggestions for further research are offered.

CHAPTER 1.

INTRODUCTION.

The words we use in natural language are usually ambiguous. Natural language is so flexible in its application that sentences can accomodate several different meanings. A useful way to conceptualise natural language processing is to see it as roughly analogous to making sense of ambiguous visual stimuli. When we encounter an ambiguous figure the perceptual system attempts to construct an appropriate interpretation for it which can be revised as alternative interpretations become apparent until the ambiguity is resolved. Some figures fail to be resolved.

Several factors have been suggested to account for the resolution of ambiguity in natural language. This study focuses on one specfic grammatical category, quantifiers, and attempts to tease out the factors that influence the process of assigning a particular meaning to sentences containing quantifiers.

The term quantifier was introduced by Frege (1848-1925). Frege used it as a formal operator in logical analyses of language. The term quantifier indicates what was , in traditional logic, called the quantity of a statement , that is whether the statement is universal eg:

"All bats are blind"

or particular (existential) eg:

"Some swans are black"

The universal quantifier is read as "For any x" or "For all x". The existential quantifier is read as "There is at least one thing x such that. . . "

More generally, the universal and existential quantifiers are operators on predicates and can be used to perform inference tasks. For example, if Px is a one-place predicate (x)Px reads "For all x, Px", and (Ex)Px reads "There is an x such that Px". This operation is called quantification. Thus predicate logic is used to represent statements about specific objects and can represent quantifiers. The premise :

"All men are mortal"

can be translated to: "Ax(man x mortal x)"

Logic can also be useful for making inferences. For example, from the following premises:

"All artists are beekeepers" (x)(Ax Bx)

"John is an artist" (Ex)(Ax)

one can infer:

"John is a beekeeper" (Ex)(Bx)

The advantages of regarding predicate logic as a representation system are that it is natural, precise and flexible (Hayes 1977). It is also modular, ie changing one rule does not affect all the others. The main disadvantage however, is that predicate logic involves a separation of representation and processing , since it does not provide a full account of heuristics. Heuristics are followed when people make spontaneous inferences, such as plausible inferences. Predicate logic is an orderly method of translating statements, but since much of natural language is inherently ambiguous the fit between logic and language is inexact.

The aim of this study is to develop a processing model of quantification that takes account of syntax and semantics.

Part 1.

Ambiguity in natural language.

Natural languages contain many local syntactic ambiguities. For example, Crain and Steedman (1985) point out that in sentence processing there is often a stage at which a choice must be made about which syntactic rule has been applied and which route the processor must follow. This point is illustrated by the following pair of sentences:

1. Have the policemen whom you saw arrived?
2. Have the policemen whom you saw dismissed!

(Marcus, 1980)

The first clause gives rise to a syntactic ambiguity which is not resolved until the latter part of the sentence. This indicates that the material following an ambiguous clause can delay the resolution of ambiguity. Some ambiguities are unresolved, so that the human sentence processing device is unable to make sense of acceptable sentences like the following:

3. The horse raced past the barn fell.
4. The boat floated down the river sank.
5. The dealer sold the forgery complained.

(Bever, 1970)

Sentences containing quantifiers are also ambiguous. Where one quantifier appears in a sentence the ambiguity is slight, but when two or more quantifiers are involved the ambiguity becomes progressively more difficult to resolve. The following examples of doubly quantified sentences should illustrate this point:

6. All philosophers have read some books.
7. Some books have been read by all philosophers.

(Johnson-Laird, 1969)

Although there is some debate about whether active and passive versions of the same sentence are always synonymous (Chomsky, 1965, Katz & Postal 1964, Ziff 1966, Katz & Martin 1967), Johnson-Laird believes that this is the result of a failure to distinguish between "probable" and "possible" analyses. For example, the "probable" analysis is the one most likely to be made given the quantifiers involved. This is known as the privileged or preferred interpretation. The "possible" analysis is the alternative interpretation which is far less likely to be chosen. Johnson-Laird argues that both these sentences are ambiguous in the same way, that is that each one means either:

8. All philosophers have read some books <u>or other</u> .

9. All philosophers have read some books <u>in particular</u> .

Each sentence has a privileged interpretation, since according to Johnson-Laird sentence 6 is more likely to receive interpretation 8, and sentence 7 is more likely to receive interpretation 9. Ioup (1974) too believes that doubly quantified sentences have a preferred interpretation. I shall return to this point later in the thesis. Models of syntactic ambiguity resolution have been formulated in the field of Artificial Intelligence. Computer languages usually incorporate a structural criterion for the resolution of ambiguity, for example "looking ahead" to the next word. A structural model like this is intuitively appealing and a number of psychologists have used similar models to account for human sentence processing. Examples of these are the "look ahead" model associated with Marcus (1980), and the attachment strategies and rule-ordering of Kimball (1973), Frazier (1978), and Frazier & Fodor (1978).

1However, it seems highly likely that human sentence processing needs to take account of semantics and context in order to resolve ambiguities, even though artificial sentence processing does not. Of crucial importance in theories of natural language processing is the question of whether syntactic analyses and semantic processing are two distinct and separate operations or whether the two interact. Crain & Steedman (1985) propose the latter. They believe that the resolution of syntactic ambiguity in natural language is the result of a close interaction with semantics and reference to the context. Syntax alone cannot adequately make sense of ambiguous sentences.

The putative autonomy of syntax and semantics is the subject of much discussion. Crain & Steedman distinguish three senses of autonomy;formal autonomy, representational autonomy, and "radical" representational non- autonomy. Formal autonomy is part of Crain & Steedman's own processing model and assumes autonomy in the sense that syntax and semantics are separate entities in the theory . Representational autonomy is the view that at some level of analysis only syntactic representations are formed, which are later metamorphosed into semantic representations. The level at which such autonomy might exist is unclear. The third version of autonomy, "radical" representational non autonomy , is espoused by Crain & Steedman. The theory is as follows:during processing the semantic interpretation is built up independently, without recourse to syntactic representation. Thus rules of syntax describe the activities of the processor in assembling a semantic analysis. Syntax merely specifies how people assemble the meaning of a sentence.

The third version has the virtue of parsimony, for if syntactic structures are simply translated into semantic ones, then it is more economical for the system to assemble the semantic interpretation directly. However, the belief that human sentence processing involves the use of far-reaching rules which govern the whole sentence rather than operate a word-by-word analysis is currently popular and has led to the assumption of some degree of representational autonomy in sentence processing. Transformational Grammar is one example of such a set of rules.

If syntax and semantics are non autonomous , then the degree to which the two interact must form an integral part of any theory of human sentence processing. Theories may be completely non-interactive, i. e. no interaction between syntax and semantics until the sentence is complete, partially interactive at some level, for example the clause or phrase, or completely interactive at the level of the word or morpheme.

The theory of representational non-autonomy can embody interaction in the following form. Syntactic processing may be the method by which a semantic representation is built, but the syntactic process itself and the resolution of ambiguities which arise during that process may rely on semantics. This said, representationally non-autonomous models of sentence processing can be completely non-interactive, for example all interpretations may be made in parallel and selection between alternatives may occur only when the process is complete. Or, some structural criterion may induce a particular interpretation, with back-tracking later if revision is necessary.

Given these possible schemes of interaction, Crain & Steedman distinguish between "weak" and "strong" interaction. The weak view of interaction, which Crain & Steedman propose, is as follows. Occasionally the syntactic processor may allow the semantic component to choose which route of analysis to follow when an instance of local ambiguity occurs. The semantic component may compare evaluations of potential analyses in the ambiguous sentence in order to resolve the ambiguity. This hypothesis would commit one to the view that syntactic processing provides competing analyses, either serially or in parallel, from which the semantic processor selects the most appropriate interpretation. Interaction occurs at the point that the interpretive processes judge the "goodness of fit" between context and the analyses made available by syntax. (Altmann & Steedman, 1988). Although this evaluation process can reject a particular analytic route, it cannot initially bias the syntactic processor in favour of any particular grammatical structure.

More radically the "strong" view of interaction holds that semantics and context actually affect which "syntactic entities" (Crain & Steedman, 1985) are proposed for selection in the first place. Semantics and context perform this task either by altering the order in which syntactic rules are applied, or by removing some syntactic rules completely so that they cannot be applied until a later stage. On this view, semantics and context govern syntactic processing by deciding which constraints the processing will operate under, and forcing the processor to ignore certain grammatical rules altogether (Altmann & Steedman, 1988).

Proponents of local ambiguity resolution via weakly interactive models must also account for potential analyses being offered either serially or in parallel. Since a weakly interactive model relies on plausibility and context to decide which path to follow, it seems inevitable that such a model needs to form interpretations in parallel , rather than considering them serially. This is because it is not possible to make a discrete judgement based on context; no sentence is absolutely predictable from context since human language is so rich and varied. The semantic processor could not function effectively if analyses were offered serially since context could not help to reject inappropriate analyses.

The concept of plausibility is a vague one, and it seems unlikely that there could be a well-defined criterion for plausibility. If this were the case, argue Crain & Steedman, then such a criterion could examine alternative analyses proposed serially under a structural rule like the Minimal Attachment Strategy of Frazier & Fodor (1978). Structures which occurred earlier in the sentence would, therefore, have a lighter processing load and a residual effect of structure would occur. If alternative choices are proposed in parallel then no such effect would occur. In order to judge plausibility the human sentence processor needs a "pragmatic, context-dependent criterion" (Crain & Steedman, 1985), since plausibility is not an all-or-none affair. A single reading cannot be rejected on the criterion of implausibility. Hence the prediction is that no ambiguity is completely structural;Crain & Steedman predict that difficulty in resolving ambiguities will result in a given context rather than a given structure. The ramifications of this for doubly quantified sentences are that people will use knowledge other than syntactic and semantic information to disambiguate the meaning of the sentences.

"Garden-path" sentences intuitively suggest that the final interpretation is chosen on the basis of "goodness of fit" to the context. The process of selecting among competing analyses is based on a fallible heuristic, and there is increased difficulty in interpreting the sentence when the heuristic device fails. Sometimes the ambiguity remains unresolved, for example when people find it impossible to comprehend grammatical sentences like:

3. The horse raced past the barn fell.

But how are "garden-paths" and other ambiguities resolved by semantics ? Crain & Steedman suggest three principles:

1. The Principle of A Priori plausibility.
2. The Principle of Referential Success.
3. The Principle of Parsimony.

The Principle of A Priori plausibility holds that if an interpretation is more plausible either with reference to general knowledge about the world or to specific knowledge about the universe of discourse, then it will be preferred to an interpretation that is not. Specific knowlege will always be more important for ambiguity resolution than general knowledge.

One kind of specific knowledge about a universe of discourse consists in the referents which are established in the listener's mental model of the universe of discourse. Several proposals have been made regarding the weak interaction between syntactic processes and reference to a mental model. For example, Winograd (1972) suggests that ambiguities like the following can be resolved according to the "goodness of fit" between the candidate Noun Phrase (NP) and the referents which exist in the listener's mental model:

10. Put (the block in the box) (on the table)

NP PP

11. Put (the block) (in the box on the table)

NP PP

i. e. if there is a block in the box then carry out actions as in 10; if this analysis fails to find an appropriate referent then carry out actions as in 11.

Crain & Steedman refer to this process as The Principle of Referential Success. If there is an interpretation that successfully refers to an entity already apparent in the listener's mental model of the domain of discourse, then this interpretation will take precedence over one that fails to find a suitable referent. Thus The Principle of Referential Success is a special case of the Principle of A Priori Plausibility.

On Winograd's model, problems will be encountered when a listener hears a sentence that contains a referent not in her mental model. For example, if a person hears the following sentence:

12. Did you see the man who walked past the window?

when the listener had not, then the listener will set up a mental model containing a suitable referent so that the next sentence:

13. Well he wasn't wearing any clothes!

is comprehensible. Winograd's method of reference would fail with sentences like 12, since there exists no established referent for "the man". To be successful Winograd's program must alter the model itself by adding a fresh entity (i. e. "the man"). Hence the process of reference is not only concerned with identifying referents already in the hearer's mental model of the domain of discourse. It also works to "accomodate" those entities that do not exist in the model, (Heim 1982), such as "the man" in sentence 12.

If several potential readings exist, none of which refer to the listener's mental model, then the listener must make a choice between candidate interpretations. Crain & Steedman propose that this process is accomplished according to The Principle of Parsimony. The Principle of Parsimony holds that "if there is a reading that carries fewer unsatisfied but consistent presuppositions or entailments than any other, then, other criteria of plausibility being equal, that reading will be adopted as most plausible by the hearer, and the presuppositions in question will be incorporated into his or her model". (Crain & Steedman, 1985). The Principle of Parsimony assumes that the listener has only one model of the domain of discourse. It includes the Principle of Referential Success and is a special case of The Principle of A Priori Plausibility.

However, Ferreira and Clifton (1988) argue for the existence of a syntactic processing module. If such a module exists, then initially it should construct a syntactic representation of a sentence without recourse to nonsyntactic elements like semantic or pragmatic information. Ferreira and Clifton do not claim , however, that higher level information regarding semantics, pragmatics and discourse structure is never consulted by the language processor. Instead they suggest a distinction between "initial" and "eventual" use of nonsyntactic information. Initially the syntactic module parses the sentence, and eventually (if neccesary) higher level information is exploited by the language processor.

That context is important in human sentence processing would seem to be self-evident. However, Altmann & Steedman (1988) warn that experimental manipulation of context is a tricky task. One difficulty is that it is often hard to decide exactly what entities exist in a mental model, and a second problem is that it is difficult to present subjects with a completely neutral context. So great care must be taken if attempts are made to discredit the interactive hypothesis. Altmann and Steedman opt for the principle of referential failure rather than referential success. The Principle of Referential Failure holds that if there is an interpretation that does not successfully refer to an entity in the listener's mental model then this interpretation will be rejected.

Work on processing needs to be considered when discussing doubly quantified sentences. Doubly quantified sentences are ambiguous, though not in the same way as, for example, "garden-path" sentences. With doubly quantified sentences the ambiguity can be resolved by deciding which quantifier has scope over the other. (The term "scope" refers to the range of effect one quantifier has over another; the term is explained in more detail in Part 3 of the Introduction.) A number of factors which affect scoping decisions have been proposed, and these are reviewed in Part 3 of the Introduction. Work on sentence processing is particularly relevant for doubly quantified sentences because it examines the effect of syntax and semantics in resolving sentence ambiguity. One of the aims of the thesis is to examine the effects of syntax and semantics on the processing of doubly quantified sentences.

This section has introduced questions which need to be answered in an investigation of doubly quantified sentences. Firstly, is it the case that doubly quantified sentences have a preferred or privileged interpretation as both Johnson-Laird and Ioup suggest? Secondly, is it true that comprehension difficulty occurs in a given context rather than with a given structure, as Crain & Steedman claim? The first question is examined in each of the experiments described in the thesis. The effect of context is considered in the Discussion section of the thesis.

Part 2.

Mental Models.

The preceding section has dealt mainly with the interpretation of single sentences according to the interaction of syntax and semantics. I turn now to a more detailed analysis of semantics. A sequence of sentences which is coherent is recognised as "text"; we refer to an incoherent set of sentences as "untext". The most obvious difference between text and untext is that in text each sentence is connected to the last;in untext this doesn't happen. Johnson-Laird (1983) reported a series of experiments in which subjects were required to reassemble muddled passages of prose in the correct order. The passages were either recipes, stories or anthropological text. Subjects were most successful with the recipes, but data from all the passages provided evidence for the existence of a structure in discourse. The basis of this structure is, in Johnson-Laird's view, that the most salient feature of a coherent discourse is that it must be possible to construct a single mental model from it.

A mental model sets up a mental description of events. Crucially, a mental model characterises a situation and its structure is closer to the situation than to the sentence. Often information left out of the sentence is added to the mental model using inferences from general knowledge. For example, in the sentence below:

14. John drove to London. The car broke down.

the fact that John drove a car to London has been inferred and so the two sentences are comprehensible ; entities are established in the mental model as the sentence is read. A sequence of sentences forms discourse when it is plausible within a framework of general knowledge. Johnson-Laird (1983) proposes that discourse is comprehended by means of propositional representations and mental models and that co-reference and consistency are essential for setting up a single mental model. Reference must be analysed at two levels of representation:at the representation of the sense of the discourse and at the representation of its significance.

A brief digression on the nature of sense and significance (or reference) is relevant at this point. Frege (1892) believed that each sign (word) had a sense associated with it which was independent of any individual's sense of a sign. For example, a universal such as "redness" has a real substantial existence, independently of being thought. Such a sense emanates from the collective unconscious. This view is known as Realism and should be contrasted with Psychologism of which Frege was a major opponent. In modern philosophy Realists also hold that physical objects exist independently of being perceived, thus Realism supports the common sense view that objects do not disappear when not being perceived.

Saussure is a modern advocate of Psychologism. He believed that a sign consisted of a form (the signifer) that is mentally linked to a concept (the signified)(Saussure, 1960). The meaning of any particular concept is ultimately dependent on what other concepts exist, so it is only possible to define a concept in terms of its relation to other concepts. Saussure's main argument against Realism is that words cannot stand for established concepts since, if this were the case each word would have exactly the same meaning across all languages. Saussure believed that the links between mental concepts and words reflect the structure of the mind, on which they depend.

Frege's account of sense and reference is not well-specified. More recent accounts of the same problem (eg Hintikka, 1963, Kripke, 1963) utilise the theory of possible worlds to make explicit the difference between sense and reference. According to these theorists possible worlds represent all the logically possible ways that the world might be. For a sentence to be true it must be true in the real world. The sense of a sentence like "Every woman reads" is illustrated by the division of the set of possible worlds into those in which the sentence is true and those in which it is false. The sense of a predicate like "reads" is the property that characterises those sets of individuals corresponding to the predicate in each possible world, since each possible world can be fractured into those sets which contain individuals who read, and those sets which contain individuals who do not read. By comparing the propositional representation of the sentence and the mental model and general knowledge, people can find out the significance of a sentence. Once referents have been identified this data can be added to the model, so the model goes beyond the literal meaning of the sentence, including as it does inferences, instantiation and reference. Because its structure is closer to the situation than the sentence, the syntactic structure of the sentence is not recoverable from the model.

So, the sense of a sentence is a proposition, and is described as a function from possible worlds to truth values; the set of possible worlds can be divided into those where the sentence is true and those where it is false. The reference of a sentence is its truth value in the particular world under consideration. Thus the critical difference between sense and reference is this : the sense of a sentence is illustrated by it being true in some possible world, while the reference of a sentence is illustrated by it being true in the actual world.

The context of a sentence can be represented in a mental model. Bransford, Barclay & Franks (1972) propose a constructive theory of semantics. They believe that people construct readings which go beyond the linguistically given information, a view which Johnson-Laird endorses. Johnson-Laird's evidence on memory for spatial descriptions (Mani & Johnson-Laird, 1982), suggests that comprehension occurs in two stages. Firstly, the superficial understanding of a sentence induces a propositional representation which is similar to the surface structure of the sentence. This representation is written in a mental language. The second stage of the comprehension process is optional. At this stage propositional representations are used to form a mental model of the situation described in the sentence. Contextual cues and inferences based on general knowledge help to form the model. Hence both semantics and pragmatics are involved in establishing a mental model.

This is evident from an experiment which Bransford & Johnson carried out in 1972. They gave three groups of subjects the following passage of text:

"The procedure is actually quite simple. First you arrange items into different groups. Of course one pile might be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities, that is the next step;otherwise, you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then one never can tell. After the procedure is completed one arranges the material into different groups again. They then can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is part of life. "

The first group of subjects were given no indication of the topic of the passage, and not surprisingly found it extremely difficult to make sense of. The second group of subjects were told that the topic of the passage was "washing clothes" after they had read it, but they too found the text difficult to comprehend. The third group were given the topic before they read the passage;this group found it easy to understand. The first and second groups were unable to establish a coherent mental model for the passage because they were not provided with the topic. For the third group the topic acted as a context so that a suitable mental model could be established.

Johnson-Laird's evidence (eg Johnson-laird & Stevenson, 1970; Cooke, 1975)indicates that the meaning of a sentence is directly recovered from its surface structure, and that the Deep Structure of a sentence is not mentally represented. An alternative approach is that of Fodor, Bever & Garrett(1974), who believe that comprehension of any sentence necessitates recovering the Deep Structure of the sentence. Deep Structure is related to surface structure by a list of grammatical transformations, but Fodor et al suggest a number of heuristic strategies which replace transformations. For example, one such heuristic treated any Noun Verb Noun arrangement as an underlying clause. Another heuristic assigned the first noun as subject, the second as object, and the verb as the main verb of a clause.

Johnson-Laird's theory of mental models is perhaps most explicit if one examines syllogistic reasoning. According to Johnson-Laird (1983) establishing a mental model results from the processes of language comprehension. Implicit textual inferences are necessarily made during comprehension. When people read a sententence like:

15. All artists are beekeepers.

they represent the meaning of "all" by constructing a set of representative examples of artists, and show that these examples are also beekeepers, as illustrated:

artist	artist	
beekeeper	beekeeper	(beekeeper)

The bracketed beekeeper shows the possibility that there are beekeepers who are not artists. The way the model is set up reflects the meaning of "all" and one could expect to find this arrangement whenever a person encountered the word. This is one example of an implicit textual inference. Implicit inferences are inductive inferences and as such facilitate the construction of a mental model of the situation so as to maintain the truth value of the situation. Implicit inferences can be deductive too. If people encounter a syllogism of the following form:

Some A are B

All B are C

The valid conclusion is Some A are C

People reach this conclusion by constructing a mental model as shown below:

$$\begin{tikzcd}
\text{Some A are B} & A \arrow[d] & (A) & \\
\text{All B are C} & B \arrow[d] & (B) \arrow[d] & \\
 & C & C & (C)
\end{tikzcd}$$

An integrated array of the two premises is formed and the valid conclusion , Some A are C, can be read off. However, since assertions can be compatible with more than one state of affairs a checking procedure is necessary. A series of "tests to destruction", an explicit deductive process, must be performed on the model to check its internal consistency. If this procedure was error-free it would constitute a decision procedure for any inference from a mental model; unfortunately it is fallible.

The theory of Mental Models predicts that when people read or hear sentences they set up a mental array as a comprehension device. More specifically, the meaning of the sentence will depend crucially on the mental model, and on how successfully the "tests to destruction" are performed. With reference to doubly-quantified sentences, the theory predicts increased difficulty as the number of possible readings increases, since the checking procedure often fails to make an exhaustive search of all potential analyses.

Johnson-Laird, Byrne & Tabossi (1989) have proposed a model for dealing with doubly quantified sentences. Their model postulates a "loop" machanism which processes doubly quantified sentences. Each quantifier has a loop associated with it which corresponds to the interpretation given to the quantifier. Johnson-Laird et al use the following sentence as one example:

"Every Avon letter is in the same place as some Bury letter. "

In order to process this sentence the program enters a loop (Loop A) for the first quantified phrase "Every Avon letter" and chooses a nominal size for the set, eg three Avon letters. Because the set is universally quantified the loop must ensure that each member of the set satisfies the predicate "is in the same place as". Loop A places an Avon letter in the model so :

/a/

The program then enters a second loop (Loop B) which is based on the quantifier "some". Because "some" is an existential quantifier the loop need only satisfy the relationship (ie "is in the same place as") for an arbitrarily sized subset of Bury letters , eg two. Other members of the set of Bury letters will be represented as not satisfying the relationship. Loop B chooses a member of its subset and places it in the model so :

/ab/

The process continues to cycle through Loop B until all the members of the subset are placed in the model :

/abb/

The program then returns to Loop A and selects the next member of its set which must satisfy the relation "is in the same place as":

/abb/a/

The program then returns to Loop B and an arbitrarily sized subset is again inserted in the model :

/ab/

The process continues until all the Avon letters appear in the model. When this process is complete the optional Bury letters which do not satisfy the relationship are added to the model :

/abb/ab/abb/ob/

Johnson-Laird et al conclude that the order in which the loops operate depends on the scope given to the quantifiers. The first loop corresponds to the quantifier with largest scope, the second loop corresponds to the quantifier with the next largest scope, and so on. However, although Johnson-Laird et al assume scope ambiguities they do not explicitly state how such ambiguities are resolved. It should also be noted that their work is concerned with reasoning using doubly quantified syllogisms.

The main question arising from this section is how successful Johnson-Laird's theory of Mental Models is in accounting for the way people interpret doubly-quantified sentences.

Part 3.

Specific theories about the comprehension of quantifiers.

The role of quantifiers is to specify how many acts or participants are involved in a situation. Fodor (1982) believes that as a child acquires language he or she must apply a set of "linguistic sieves" to their perceptions so as to isolate those features of the world that can be contained in sentences. If the transition between mentally representing perceptions, and the structure of sentences occurs as a result of counting acts or actors in the represented situation and inserting them into syntactic slots in the sentence structure then ambiguities will result. Scope ambiguities, argues Fodor, are the result of degrees of freedom involved in the sieving process.

Specifically Fodor predicts that a quantifier will have scope over another quantifier as long as it c-commands that quantifier in the semantic representation. The term c-command, or in full constituent-command, was introduced by Reinhart (1976). Reinhart gives a simplified definition of the term:

"Node A c-commands node B iff the branching node most immediately dominating A also dominates B. "

The term "scope" refers to the range of effect one quantifier has over another. For example, if "every" takes wide scope in the sentence below :

"Every child saw a dog. "

then the sentence can be represented schematically like this :

```
child------dog
child------dog
child------dog
      saw
```

In this interpretation "every" induces a multiple representation of its own noun phrase and the verb associated with it. Conversely if "a" takes wide scope in the same sentence the representation will be :

```
child-----dog
         / /
child   / /
       /
child

     saw
```

Fodor also predicts that the earlier a quantifier occurs in a surface sentence, the wider its scope is likely to be. Preferred scope readings will be those in which the quantifiers move as short a distance as possible, and leftward movements for the hearer are favoured. Preferences are due to sentence comprehension processes, the preferred reading being the one that people find easiest to compute.

According to Fodor certain interpretations of quantified sentences require no special mental effort. Those which do need modifications to their sentence structure are marked or difficult to compute. Any feature system, i. e. a system which ascribes a set value to a particular quantifier (see for example Enderton, 1972), which attempts to describe quantifier scope must reflect the dependence relations that exist between quantifiers. For example the reading of quantifier A that is within the scope of quantifier B is dependent on the presence of B. Fodor argues that the features used to describe quantifier scope cannot be binary features since this would lead to the prediction that a sentence with n quantifiers has 2n logically possible interpretations. This is incorrect, since a sentence containing one quantifier has only one interpretation and not two, while a sentence containing three quantifiers has a maximum of six possible interpretations. To make the number of possible interpretations match the number of quantifiers in a given sentence the features used to describe the sentence must apply to individual sentences.

Any feature representation system must be sensitive to the surface structure of a sentence. Fodor suggests that features derived from universal and existential quantifiers could be used to explain scope relations;positive values from quantifiers which occur later in the sentence could be given to earlier quantifiers which would, therefore, be taken as within the scope of the later quantifier.

In terms of sentence processing, this system suggests that it is easier for someone who has encountered a universal quantifier in a sentence to extend the scope of that quantifier as far forwards as possible, but not backwards over the sentence as this will require special mental computations. These extra mental procedures are needed because in order to extend scope backwards it is necessary to revise the semantic representation (mental model) already constructed. Fodor points out, however, that it is also psychologically costly to terminate the forward scope of a universal quantifier. The reasons for this are less obvious, and Fodor attempts to explain them through Models of the World Representations. Fodor's predictions are examined in detail in the following section.

Models of the World Representations.

Fodor distinguishes between EA readings and AE readings schematically. (The EA reading is one in which the existential has highest scope; the capital letters represent the logical notation for "Existential / Universal". The AE reading is one in which the universal has highest scope; here the capitals represent Universal / Existential). For example, the sentence :

16. Every child saw a squirrel.

has two possible readings:

```
a) c\
     \
c----->s   EA reading (the existential quantifier has highest scope).
     /
c  /

b) c------s

c------s   AE reading  (the universal quantifier has highest scope).

c------s
```

These "models of the world" have the advantage of showing exactly how each phrase should be instantiated and also clearly reveal inherent scope ambiguities. Fodor believes that such representations are the result of the sieving process which children learn to apply. Perhaps Fodor's strongest claim is that these schematic representations are not simply visual aids to comprehension but that people construct such schema as semantic representations of quantified sentences.

These schematic representations provide explanations for some traditional problems associated with the interpretation of quantified sentences, on Fodor's account. Quantifiers are interpreted "in situ" as in the feature systems but because they do not move there is no need to account for where or how far they are allowed to move. The scope of a quantifier may extend forwards or backwards over a sentence. As in the Skolem-type systems (see Enderton, 1972), only universal or other multiple quantifiers can have scope over other quantifiers. A multiple quantifier has scope over part of a sentence if it causes a multiple representation over that part of the sentence.

For example in b) above the quantifier "every" has caused a multiple representation not only of "child" but also of the verb and the object noun phrase. In a), however, it has caused a multiple representation only of its own noun and the verb.

Schematic representations can clarify the relative difficulty of readings in which the scope of a multiple quantifier travels backwards over earlier parts of the sentence, a difficulty to which I referred in the preceding section. For example, the AE reading for the sentence:

17. A child saw every squirrel.

will be prepared on-line in the following way. Firstly "a child" receives the singular interpretation. This interpretation must be modified when the universal quantifier is encountered. For example:

```
Step 1.   "A child saw every squirrel"

          c------                    (just one entity is established).

            saw

Step 2.    Revise:

          c------s                   (more "c" entities are required

          c------s                    when "every" is encountered).

          c------s

             saw
```

It is less psychologically extravagant to compute the following representation which is the EA reading, since no revision is necessary:

```
                                  /s
                                 /
       c----- -------> c<------s
                                 \
         saw                      \s
```

saw

Forward scope of the multiple quantifier is easy to compute since in a sentence like:

18. Every child saw a squirrel.

all that is required is that the multiple paths established for "every child" be extended to later words in the sentence as they occur:

```
c------                 c------s
c------      ------>    c------s
c------                 c------s
  saw                     saw
```

It is possible that to save time a person might employ the strategy of making the barest representation of a sentence, to be filled in later if more information is needed, for example for inference tasks:

```
c------s
c. . . (ditto)
c. . .
   saw
```

If this were the case , Fodor argues, then it would explain why the scope of a multiple quantifier usually extends forwards over a sentence. In order to terminate its scope the person must form a representation of the following type:

```
c
  \  \
       \
c----->s
     /
  / /
c
    saw
```

The "ditto" strategy is insufficient to compute this representation since the multiple paths must be clearly represented. Thus a person who has used the strategy must revise his or her model, using extra processing time. On Fodor's account, therefore, the EA reading, (termed "converging") in my experiments) should be slower than the AE ("diverging") reading when the order of the quantifiers is "every / a".

Fodor also believes that the marked prosodic contours which occur with reversed readings are compatible with her schematic representation system. For example, when the surface structure contains a multiple quantifier followed by a singular quantifier, the reversed reading will correspond to a converging representation, i. e. one in which the single entity is not included in the multiple paths constructed earlier. In Fodor's view the prosodic break would signal the dissociation of the single entity from the multiple paths.

Conversely when the surface structure contains a singular quantifier followed by a multiple quantifier the reversed reading would need to establish multiple paths from the singular quantifier. In order to make this task easier the prosodic contour should be such that it encourages the listener to delay processing earlier parts of the sentence until the multiple quantifier is deciphered. Cutler & Fodor (1979) found some evidence that focussed phrases are the first to be interpreted; this evidence would be compatible with the type of prosodic contour observed in doubly-quantified sentences by Jackendoff (1972), and Lasnik (1975).

A further benefit of Fodor's schematic representation system is that the distinction between collective and distributive action can be accounted for as a scope relation between quantifiers and verbs. In earlier representation systems quantifiers are moved to the front of a clause of the logical representation but verbs stay within the clausal representation;thus every quantifier has scope over the verb in its own clause. This means that a sentence like:

19. All the children lifted a rock.

cannot be represented without extra mental footnotes;merely prefixing the quantifiers would lead to the interpretation that there are as many acts of lifting as there are children.

However, the model of the world system provides three different representations of the sentence,each of which give a varying degree of forwards scope to the universal quantifier:

a)
c...______...r
c...______...r each child lifted a different rock.
c...______...r
lifted

b)
c...______
c...______...r each child (separately) lifted the same rock.
c...______
lifted

c)
c
c...______...r the children collectively lifted a rock.
c
lifted

In a & b the verb is multiply interpreted;in c the multiple paths meet before the verb and the reading signifies collective action.

The unification of scope over verbs with scope over other quantifiers leads Fodor to describe the differences which exist among the universal quantifiers "each", "every" and "all". "Each" must take scope over at least one item other than the nominal it is associated with. If it does not the resulting sentence will be ill-formed, for example:

20. *Each soldier surrounded the fort.

In this sentence the verb describes collective action and is, therefore, inconsistent with the quantifier which indicates individual action. It does not make sense for an individual soldier to surround the fort. "Each" needs to take scope over the verb in order for the sentence to be plausible but in this case it is unable to do so. If the word "attacked" was substituted for "surrounded" then the resulting sentence would be well formed because "each" can take scope over the new verb. In sentence 20 the multiple paths associated with "each" need to converge immediately after "soldier" and before other items in the sentence. The necessary rule is not so strict for "every" and is even less so for "everybody", "everyone" etc. For "all" there is no such requirement. These points are demonstrated below:

21. ??Every soldier surrounded the fort.

22. ?Everyone surrounded the fort.

23. All the soldiers surrounded the fort.

According to Fodor these observed differences between multiple quantifiers are one indication of what she terms the relative "hunger" of each for inducing a multiplicity of paths in a representation. For example, "each" is the hungriest, "all" the least hungry. "Each" tends to extend its scope further in both directions than other quantifiers. This view is shared by Ioup (1975), who also proposes that each and every tend to have highest scope no matter wherever they occur in a sentence, particularly each.

According to Ioup : "Scope refers to the range of effect that a logical element, such as a quantifier, has on the remaining members of an expression..... Relative scope [refers] to the interaction of two logical elements in a string where the domain of influence of one is affected by that of the other". She proposes that three elements interact to determine which quantifier has highest scope within a clause. In order of importance these are:

1. The inherent characteristics of individual quantifiers.
2. Their grammatical function within the clause.
3. Their location in a salient serial position in the sentence.

1. <u>The inherent characteristics of quantifiers</u>.

Ioup and Fodor agree that some quantifiers, especially "each" and "every" tend to be assigned highest scope no matter where they occur in a sentence. In the following examples "each" and "every" occur to the right of the second noun phrase and also in a prepositional phrase dependent on it, and yet the preferred reading is one in which "each" and "every" has highest scope.

26. I saw a picture of each child.

27. She knows a solution to every problem.

28. Ethel has a dress for every occasion.

(Ioup, 1975)

However, if "all" is substituted for "each" or "every" the preferred reading is to assign highest scope to the indefinite article.

29. I saw a picture of all the children.

30. She knows a solution to all problems.

31. Ethel has a dress for all occasions.

(Ioup, 1975)

The differences in scope readings which occur with different quantifiers lead Ioup to propose a hierarchy of quantifiers that tend to have highest scope regardless of other components in the sentence. At the top of this hierarchy are the universal quantifiers with distributive properties. Then Ioup believes that quantifiers which define larger sets will appear in the hierarchy, while those which identify smaller sets will be lower down the scale. "A" and "some" followed by a singular noun phrase are exceptions. These quantifiers appear to be preceded only by "each" and "every" in the hierarchy but Ioup's data is not conclusive and so these two are omitted from the hierarchy.

Figure 1. Hierarchy of quantifiers.

Greatest inherent tendency towards highest scope.

EACH

EVERY

ALL

MOST

MANY

SEVERAL

SOME (+NPpl)

A FEW

Least inherent tendency towards highest scope.

(after Ioup, 1975)

The hierarchy is illustrated by the following sentences:

32. John gave a few handouts to some pedestrians.

33. John gave a few handouts to several pedestrians.

34. John gave a few handouts to many pedestrians.

35. John gave a few handouts to all the pedestrians.

36. John gave a few handouts to every pedestrian.

In 32 it seems that the number of handouts is small and that each pedestrian received one. As the quantifiers get larger the preferred reading alters and the tendency is to interpret the sentences as if each pedestrian received more than one handout. In 35 & 36 it becomes obvious that each pedestrian received a few handouts.

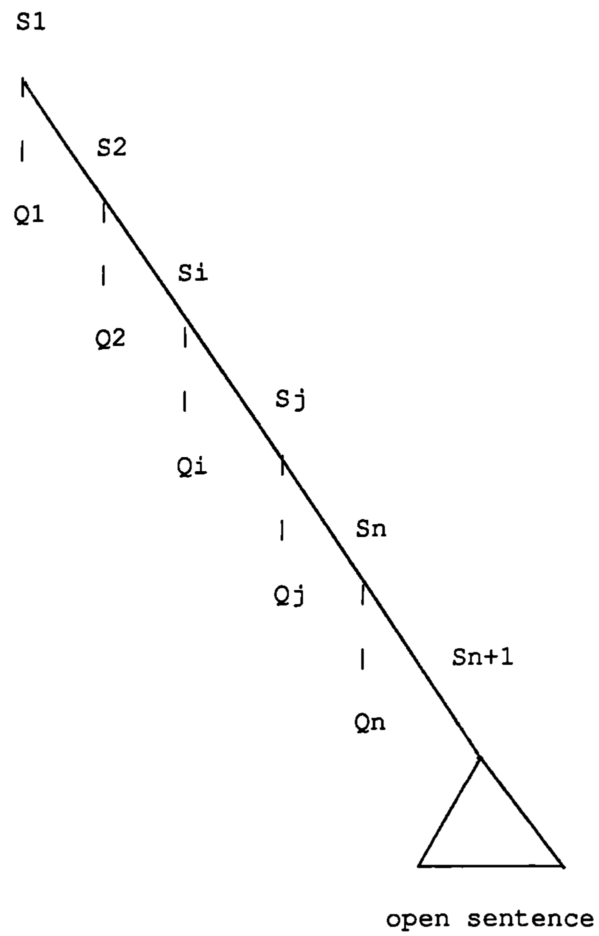
2. The grammatical function of quantifiers.

The second of Ioup's elements for defining scope is the grammatical function of the quantifier. Again Ioup establishes a hierarchy.

Figure 2. Hierarchy of grammatical function.

deep & surface subject > deep subject OR surface subject > indirect object > preposition object > direct object.

Ioup uses a deep structure model developed by Keenan (1972) to explain what it means for a quantifier to be assigned higher scope. Semantically "Qi has higher scope than Qj" means that the remainder of the sentence dominated by the S-node that immediately dominates Qi (and contains Qj) will be interpreted as an instance for every member of the set defined by Qi. This argument is schematically represented overleaf.



or: (Q1 (Q2 (...Qi (...Qj (...Qn (Sn+1)) Sn...) Sj...) Si...) S2) S1)

The following sentence should clarify this point:

37. All the women built a garage.

If "all the women" is given highest scope then "built a garage" applies to each of the women included in the interpretation; thus there can be as many garages as there are women. This interpretation gives highest scope to the plural quantifier (Qpl), and Ioup refers to it as the Individual (I) interpretation. On Fodor's model the sentence would receive the AE reading and would be represented schematically as shown below:

w-----g

w-----g

w-----g

built

If "all the women"is given lower scope than "built a garage" then the quantified phrase will be included in the predicate for each member of the set "a garage". Each time the predicate applies the women will be referred to as a group. Since there is only one garage mentioned in the sentence, if "the garage" receives highest scope then the interpretation must be that all the women work collectively to build it. This interpretation, where the indefinite noun phrase (Qsing) gets highest scope is termed the Collective (C) interpretation. This is the EA reading and Fodor's model would be the following:

```
w\
   \
    \
w---->g
    /
   /
w/

 built
```

Ioup gives several example sentences in support of her claim that subjects take precedence over direct objects in scope assignments. Each sentence contains the same two noun phrases, one quantified by "every" , the other by "a" but the deep and surface grammatical positions of the noun phrases vary:

38. Every girl took a chemistry course. (I interpretation only, every has highest scope).

39. A chemistry course was taken by every girl. (I preferred).

40. Every chemistry course was taken by a girl. (I preferred).

41. A girl took every chemistry course. (C interpretation preferred).

In 38 the universal is both deep and surface subject, in 38 it is deep subject, in 40 surface subject, and in 41 deep and surface object. Order does not cause the changes in interpretation; 38 and 40 have the same surface order of quantifiers but 40 is ambiguous and allows a reading where the rightmost quantifier, Q(sing), has highest scope, (

a C interpretation).

In 39 and 41 the quantifiers have the same surface order but 39 has a preferred I interpretation giving Q(pl) highest scope and 41 has a C interpretation giving Q(sing) highest scope. 39 and 40 have opposite quantifier ordering but identical preferred and permitted readings.

Ioup gives examples to show that the indirect object position takes precedence over the direct object position:

42. I told every child a story. (I interpretation preferred)

43. I told every story to a child. (C preferred)

44. I told a story to every child. (I preferred)

45. I told a child every story. (C preferred)

Both 42 and 44 have a preferred reading in which a possibly different story is told to each child; the I interpretation;43 and 45 favour a C interpretation. In these two sentences the indefinite article occurs with the indirect object rather than the direct object and it is the indirect object that is assigned highest scope on the preferred reading. In all four sentences the indirect object takes precedence over the direct object. Evidence also suggests that the preposition object takes precedence over the direct object:

46. I had many conversations with a friend. (C only)

47. I had a conversation with many friends. (ambiguous)

48. Freddy hit many balls with a bat. (C only)

49. Freddy hit a ball with many bats. (ambiguous)

In 46 and 48 the singular quantifier(Qsg) occurs in preposition object position and is assigned highest scope, though it appears rightmost in the sentence. However, when the plural quantifier (Qpl) is in preposition object position the sentences are ambiguous and on one reading the Qsg, though leftmost, can be assigned lower scope. Data from other languages supports Ioup's claims but also suggests that another category be added to the hierarchy of grammatical functions;that of topic.

Although there is no well-defined way to refer to topic in English other languages do have a specific grammatical category for topic. Ioup's data from for example Japanese and Iranian suggests that "topic" should precede "subject" on the scale of grammatical functions. A revised hierarchy should, therefore, be formed:

Figure 3. Revised hierarchy of Grammatical Functions.

Topic > deep and surface subject > Deep OR surface subject >indirect object > preposition object > direct object.

---

3. Location of quantifier in salient serial position.

Ioup believes that topic and subject are at the top of the hierarchy for the following reasons. In all the languages on which she collected data focus is accomplished by moving an element either to the front or to the end of a sentence. In most languages this is subject position. Ioup claims that topic and subject have greatest tendency towards highest scope because they occur in a salient position in the sentence. Sentences are subject to the serial position effect where items at the beginning and end of a string are well remembered. Languages exploit this phenomenon to convey important information, so the noun phrase with the highest scope is likely to be found at either end of the sentence. In English the first position in a sentence is normally used to signal important information, so researchers who have studied only English have been misled into believing that left-right ordering is what determines quantifier scope. If a variety of languages is examined it appears that the leftmost position in English is simply a means of signalling important grammatical information.

Johnson-Laird would disagree with Ioup's position, since he believes that a bias towards one interpretation can be produced by word order. His explanation for the fact that sentences have different privileged interpretations is based on the quantificational calculus. If x = books, y = philosophers and R = reading then one can express the interpretation of sentences in the following form:

Every philosopher has read some books (or other): (x) (Ey) (xRy)

There are some books (in particular) that every philosopher has read: (Ey) (x) (xRy)

Since these symbolic representations of the privileged interpretations of the two sentences have their quantifiers in the same order as the sentences Johnson-Laird reasons that word order determines which interpretation is privileged. When "some" occurs first in a sentence it is more salient and the extra emphasis on the word pushes focus onto the "some in particular" interpretation. The opposite argument applies when the existential quantifier follows the universal quantifier.

Johnson-Laird tested his theory using a variety of logically complex sentences (Johnson-Laird, 1969). Subjects saw 64 sentences and for each sentence ten diagrams, representing different states of affairs, had to be classified as truthfully or falsely representing the sentence. The experimental material was chosen so as to exploit three variables: polarity, voice (i. e. active or passive) and word order (i. e, whether "some" is surface subject or object of the sentence).

The ten diagrams took the form of matrices in which the rows represented the logical (deep structure) subject of the sentence and the columns represented the logical object of the sentence.

Johnson-Laird predicted that subjects would give each sentence its privileged interpretation and then classify the matrices in a strictly logical fashion. He also predicted that negatives would cause more difficulty than affirmatives (negatives are traditionally more difficult, see e. g. Wason, 1959, 1961, unless they occur in plausible contexts, Wason 1965), that passives will cause more difficulty than actives (see e. g. McMahon, 1963, Gough 1965, Slobin 1966). A further prediction was that the privileged interpretation should be easiest to make when "some" is the grammatical subject than when it is grammatical object. This is because when "some" appears in object position it is taken to mean "some or other" by default on the basis that if "some" is not the subject then it does not mean "some in particular".

Results confirmed these predictions. Subjects consistently made the privileged interpretations, with active and passive sentences inducing different interpretations. As predicted the privileged interpretation resulted more often when "some" was in subject rather than object position. An interesting result was that "some"(NPsing) was rarely interpreted to mean a single entity.

Since both privileged and unprivileged interpretations occur, subjects must use both deep and surface processing of the sentences. Clark & Begun (1968) show that both levels of processing occur when subjects are required to detect or correct semantic anomalies. Katz & Postal

(1964) proposed that all semantic interpretation is performed at deep structure and, therefore, grammatical transformations do not change meaning. In performance then, the listener may need only to grasp deep structure in order to comprehend the sentence;the assignment of surface structure would occur only so far as was necessary for the assignment of deep structure and would not be held in memory for any length of time. This is in agreement with the fact that people remember gist and not syntax.

However, Johnson-Laird argues that the results of his experiment challenge this view. He believes that left-to-right processing is important because it "biases the interpretive machinery". Surface structure provides clues to deep structure but such clues, for example word order, can lead to only one interpretation of an ambiguous sentence. As yet there is no account of the semantics of quantifiers, and Johnson-Laird believes it is possible that the ways in which quantifiers are either introduced into deep structure or changed when deep structures are transformed into surface structures would show important differences in the deep structures of voice-correlated sentences. One drawback with the experiment is that the experimental task was very complex and the possibility of error on the subjects' part correspondingly high.

Johnson-Laird's research proposes that the preferred interpretation of a doubly quantified sentence depends on word order. This proposal is investigated in the thesis. The thesis also investigates Ioup's hierarchy of quantifiers and her hierarchy of grammatical function and examines whether these can be confirmed.

Part4.

Quantifiers and focus.

As was seen in part 3 Ioup argued that set size was important for her hierarchy of quantifiers. Moxey and Sanford (1987) have examined this issue in detail. Quantifiers identify different proportions of sets;for example "few" identifies a smaller proportion of a set than "many". However, Moxey and Sanford believe that different quantifiers may identify similar proportions of sets and yet give rise to different representations when they are used i. e. quantifiers control what the listener attends to. According to Sanford & Garrod (1981) to be "in focus" is to be "readily accessible and available in a mental representation" and certain expressions bring into focus different subsets of the supersets upon which they operate. This point is illustrated in the following sentences:

50. Few of our customers are disappointed.

51. A few of our customers are disappointed.

In sentence 50 the focus is on the majority of satisfied customers, or what Moxey and Sanford call the Complement Set (compset). In 51 the emphasis falls on the small number of disappointed customers, the Reference Set (refset). If quantifiers control what is in focus then they have an important function both in comprehension of language and in reasoning following discourse in which they appear, and an account of the semantics of quantifiers must include adequate reference to focus.

In order to discover what is in focus (i. e. what is in the mental model of a discourse) Moxey & Sanford gave subjects a sentence containing a quantity expression and asked them to write a subsequent sentence. If this sentence referred to some entity in the experimental sentence then Moxey and Sanford concluded that that entity was in focus. One example of an experimental sentence, with possible continuations, is given below:

52. A few of the children ate their ice-cream. They ate the strawberry flavour first.

53. *A few of the children ate their ice-cream. They threw it around the room instead.

In 52 "they" refers to the children who ate the ice-cream (the refset), so the refset may be said to be in focus. Conversely in 53 "they" refers to those children who did not eat the ice-cream (the compset), a reading which is not acceptable.

Moxey & Sanford examined quantifiers which identify small proportions, such as "a few", "only a few", "very few", "few" and "not many". These are all termed "quantity expressions". Besides identifying different proportions, these quantity expressions vary along two main dimensions. Firstly they serve different "comment" functions. For example "only a few" seems to be a comment on the small number identified;it suggests more were expected. "Few" has a similar effect, though "a few" seems less marked and simply introduces a small number of entities into the discourse. "Not many" draws attention to the small number of entities under discussion. Secondly some quantity expressions are negative and some are positive, as can be seen from the sentences below:

54. Few of the guests enjoyed the party, did they?

55. Very few of the guests enjoyed the party, did they?

56. Not many of the guests enjoyed the party, did they?

57. A few of the guests enjoyed the party, didn't they?

58. Only a few of the guests enjoyed the party, didn't they?

The tag questions at the end of these examples indicate that the first three quantity expressions are positive, while the last two are negative.

Moxey & Sanford examined the continuations which followed sentences beginning with "few", "very few", "only a few", and "a few". The full-stop followed by "they" was the control condition;the other connectives used were "and", "but" and "because", all followed by "they".

Using the full-stop condition as a baseline measure, Moxey & Sanford found the following results. "Few" biases people towards the compset, especially when coupled with "very" though this is not statistically reliable. This bias need not necessarily occur and so does not constitute a semantic rule. "A few" and "only a few" put focus on the refset. These effects combine with connective. "But" reduces the tendency for compset focus but does not exclude it altogether. "And" removes compset focus in most cases , so "and" & "but" seem to favour the refset.

"Because" needs a reason for some action as one of its arguments and this increases the amount of compset continuations. Moxey & Sanford noted that "only a few" rarely had compset continuations when combined with connectives other than "because". Compset references are not necessitated, however, by the combination of "only a few" and "because" since refset continuations are also found. In a further study Moxey and Sanford found that "not many" showed a pattern of response similar to that which had occurred with "few".

Negative quantity expressions seem to lead to compset references, while positive ones seem to lead to refset continuations;again Moxey & Sanford see this as a tendency rather than a semantic rule. For example in the full-stop condition "few" led to compset continuations in 2/3rds of cases; it allows compset continuations but does not require them. Similar arguments apply to "very few". Thus compset or refset foci must be considered tendencies rather than be governed by semantic rules.

Moxey & Sanford went on to analyse the content of continuations. They believe that certain quantifiers serve as comments on the small number signified by the quantifier. To test this hypothesis Moxey & Sanford had four categories to describe the content of continuations:

a) Reason there (i. e. reason for the predicate holding of a group).

b) Reason not there (reason for predicate not holding of a group).

c) Consequence of the number.

d) Other.

For example, the sentences "Few of the football fans went to the match. They watched it on television instead. " would fall into category b. By analysing the data in this way Moxey & Sanford found the following results. "Few" and "very few" are more likely to produce continuations giving "reasons not there" under the full-stop condition. "A few" and "only a few" do not produce continuations in categories a-c. The combination of "but" with "few" leads to "consequence of the number" continuations. Moxey & Sanford argue this shows that "few" and "only a few" serve as comment indicators on small proportions.

There also exists a subtle difference in effect between "a few" and "only a few". When "a few" is combined with "but" cause-or-effect continuations (i. e. categories a-c) are not prevalent but with "only a few" and "but" such continuations frequently occur as "consequence of small number". When the connective is "because" , "only a few" produces "reasons not there", as do "few" and "very few". "A few" leads to "reasons there" which is logically required by the connective. "Not many" leads to a similar pattern of response as "few". Moxey & Sanford conclude that "very few", "few" and "not many" more forcefully signal a comment on small number than does "only a few". Since "a few" does not induce cause-or effect responses it cannot be considered a comment.

A further variable which appears to affect focus patterns is affectivity. An affective allows the use of items like "any" and "anymore" in declarative sentences. For example the quantity expression in the following sentence is affective:

59. Few students go on strike anymore.

but the following quantity expression is not:

60. *A few students go on strike anymore.

(Sanford, Moxey & Barton, 1987).

Moxey & Sanford's results showed that "only a few" which licenses compsets, is positive and affective;they tentatively conclude, therefore, that affectivity licenses compset references.

To conclude, Moxey & Sanford believe that the relationship between focus and the rhetorical functions of quantity expressions plays an important role in language comprehension. Quantity expressions have dramatic effects on the contents of focus. The expressions which induce compset reference indicate that a comment is being made about the proportion the quantity expression signifies and serve to expose the subset of which the predicate would be taken as false in normal discourse. The impact of using different quantity expressions can be crucial as Moxey & Sanford illustrate with the example of the successful car salesman:

61. Few of our cars break down within the first two years of purchase.

Contrast this with the words of the salesman bound for bankruptcy:

62. A few of our cars break down within the first two years of purchase.

Although not investigated directly reference will be made to Sanford and Moxey's work in the Discussion section of the thesis.

Part 5.

Quantifiers and Context.

In common with Sanford and Moxey, Newstead believes that context affects the interpretation of quantifiers. He argues (Newstead, 1988) that outside artificial languages quantifiers are "fuzzy concepts", ie they do not have a precise definition. Nor, according to Newstead, is their meaning stable. Rather, the meaning a quantifier has varies according to the situation in which the quantifier is used.

One factor which affects the interpretation of a quantifier is expected frequency. Pepper and Prytulak (1974) found that when a quantifier referred to a high frequency event or context, the quantifier was interpreted as indicating a higher frequency. For example, "frequently" was interpreted as about 70% of the time when used to describe the frequency with which Miss Sweden was found attractive; this context has a high expected frequency. Conversely, "frequently" apparently meant only about 20% when used to refer to the incidence of air crashes, a low expected frequency event. Newstead and Collis (1987) replicated these findings.

It seems also that experience and attitude influence the interpretation of quantifiers. Goocher (1965) found that people who disliked dancing thought going dancing once a month "often", while keen dancers regarded the same frequency as "seldom". This point is perhaps best illustrated in a scene from the Woody Allen film "Annie Hall". On being asked by their respective therapists how many times a week they have sex, the two characters respond:

Diane Keaton : "Constantly. . . . . three times a week".

Woody Allen : "Hardly ever. . . . . .three times a week".

Hormann (1983) found that other factors influence the interpretation of quantifiers. These include:

1. Object described : a few crumbs suggests more than 8; a few shirts is approximately 4.

2. Size of object : a few large cars suggests a lower number than a few cars.

3. Spatial location : a few people standing in front of a hut indicates a lower figure than a few people standing in front of a building.

4. Field of vision : a few people seen through a peephole suggests a lower number than a few people seen through a window.

(Newstead, 1988.)

Set size also affects the interpretation of quantifiers. Newstead, Pollard and Riezeboz (1987) found that quantifiers like "few", which indicate a small number, were interpreted as referring to larger proportions with small set sizes than with large set sizes.

The range of quantifiers available also affects the reader's interpretation. For example, Newstead and Griggs (1984) found that "some" was rated as more appropriate with proportions between 50% and 100% when it occurred alone than when an alternative quantifier "most" was also available. Nevertheless, Newstead and Collis (1987) found that the number of other quantifiers available is of limited effect if the quantifiers that are available follow a balanced path over a particular dimension.

Taken together, these factors suggest a strong effect of context on the interpretation of quantifiers. Context factors include the expected frequency of an event, the type of activity, the set size described and the range of quantifiers available to the reader. Newstead argues, therefore, that it is not possible to establish the meaning of a quantifier. Instead one must realise that for each quantifier a range of meanings exists. The researcher's task is to discover those variables which predict a particular interpretation.

Summary.

It is evident from issues raised in the Introduction that both syntax and semantics play a part in determining quantifier scope. However, the experiments in the thesis primarily examine scoping decisions under different syntactic conditions, and the discussion sections following each set of experiments reflect this choice. The experiments described in the thesis focus on syntactic manipulations and the wider issues of context and general knowledge will be returned to in the Discussion section of the thesis.

To summarise then, the thesis will attempt to test the theories which have been proposed to account for quantifier scope. These are the work of Johnson-Laird, particularly on the influence of word order on quantifier scope, the work of Fodor on the proposed representation of doubly quantified sentences, and Ioup's work on the inherent characteristics of quantifiers and their grammatical function. The experiments contained in the thesis form three sets. The first set of experiments investigated the effect of word order and type of quantifier on scope. These experiments are referred to as "drawing tasks" since people were required to illustrate their interpretation of doubly quantified sentences. The second set of experiments is referred to as "subject / predicate" evaluations. These experiments looked at the effect of word order, quantifier type and grammatical function on scoping decisions. They required that people made a judgement about a diagram representing each doubly quantified sentence. The final set of experiments are "dative" evaluations , and pronoun and noun phrase reading tasks. These experiments investigated the effects of word order and the characteristics of individual quantifiers on quantifier scope. The effect of continuation sentences was also examined in this set of experiments.

CHAPTER 2.

DRAWING TASKS.

EXPERIMENT 1 (PILOT).

INTRODUCTION

Experiment 1 investigated some of the factors which influence the interpretation people give to sentences containing two quantifiers. Because such sentences are ambiguous they can have more than one reading; the aim of Experiment 1 was to examine the factors that cause one reading rather than another.

The interpretation of quantified sentences was investigated by manipulating two variables, word order and quantifier type. Word order was manipulated by including active sentences, eg:

"A pupil admires all teachers."

and their corresponding passives, eg:

"All teachers are admired by a pupil."

The effect of quantifier type was examined by including both universal and existential quantifiers. There were two universal quantifiers, "all" and "every", and three existential quantifiers, "a", "some" followed by a singular noun phrase,eg "some pupil", and "some" followed by a plural noun phrase, eg "some pupils" (afterwards referred to as "some(pl)". This gave sentences such as :

"A pupil admires all teachers."

"A pupil admires every teacher."

"Some pupil admires all teachers."

"Some pupil admires every teacher."

"Some pupils admire all teachers."

"Some pupils admire every teacher."

together with their corresponding passives.

There are a number of predictions which arise from these manipulations. Firstly, in the case of word order Johnson-Laird would predict an interaction between order of quantifier and type of interpretation (converging or diverging). That is, when the universal quantifier occurs first, the diverging reading will be preferred, and when the universal occurs second the converging reading will be 6referred. Diverging readings are those in which the universal quantifier takes wide scope and converging readings are those in which the existential takes wide scope. Fodor also believes that the earlier a quantifier occurs in a sentence the more likely it is to take wide scope.

In the case of quantifier type, in particular type of universal, the prediction is as follows. Ioup argues that "every" tends to take highest scope regardless of where it occurs in a sentence, and both Ioup and Fodor believe that "every" is more likely to take wide scope than "all" is. One would, therefore, predict that sentences containing "every" will result in more diverging readings than sentences containing "all". The tendency for "every" to take wide scope may interact with word order so that the effect is greater when "every" is in first position.

As an additional observation, the experiment tested whether more converging readings were made with "a", "some" or "some(pl)".

All the experimental sentences contained concrete nouns and were chosen so as to reduce the possiblity that subjects would have strong expectations about their content. The lexical material varied across sentences.

METHOD, EXPERIMENT 1.

SUBJECTS.

Twelve undergraduate students from the University of Durham took part in the experiment.None had had tuition in Logic or Linguistics.

MATERIALS.

Subjects were given twelve sheets of paper, each with a doubly quantified sentence typed at the top. The sheets had a large blank area below the typed sentence so that subjects could draw a diagrammatic representation of the sentence.

Example sentences are shown below.

Condition.	Example sentence.
Universal 2nd	
A...........all	1. A pupil admires all teachers.
A.........every	2. A pupil admires every teacher.
Some........all	3. Some pupil admires all teachers.
Some......every	4. Some pupil admires every teacher.
Some(pl)....all	5. Some pupils admire all teachers.
Some(pl)..every	6. Some pupils admire every teacher.
Universal 1st.	
All...........a	7. All teachers are admired by a pupil.
Every.........a	8. Every teacher is admired by a pupil.
All........some	9. All teachers are admired by some pupil.
Every......some	10. Every teacher is admired by some pupil.
All....some(pl)	11. All teachers are admired by some pupils.
Every..some(pl)	12. Every teacher is admired by some pupils.

A complete list of the sentences used in this experiment can be found in Appendix 1(a).

DESIGN.

Experiment 1 investigated three factors:

1. Word order : Universal quantifier first vs Universal quantifier second.

2. Type of Universal : All vs Every.

3. Type of existential : A vs Some.

These factors gave a total of 8 experimental conditions. However, the experimenter also included sentences in which "some" was followed by a plural noun phrase as in sentences 5,6,11 & 12 above, eg "Some pupils admire all teachers". This manipulation was included to investigate whether a difference in interpretation occurred between "some" followed by a singular noun phrase and "some" followed by a plural noun phrase. This gave a total of 12 experimental conditions. An example sentence for each condition can be found in the "Materials" section.

Twelve experimental lists were prepared. Every list consisted of twelve sentences, one in each condition. Sentences were assigned to conditions by means of a matrix which ensured that each subject saw one example of each sentence type. There were 12 subjects.
The sentences were typed onto separate sheets of paper and subjects were asked to draw a representation of the sentence using initial letters and arrows, eg:

converging diverging

The experimenter constructed a set of diagrams for the experimental sentences. The diagrams represented the converging and diverging reading for each sentence, and subjects' drawings were matched against these diagrams on completion of the experiment.

PROCEDURE.

Subjects were given a printed sheet of instructions as follows :

"I would like you to read the sentences printed on these sheets one at a time. After each one I would like you to draw a diagram representing the sentence. Here is an example :

"Every man loves a woman."

```
M----->W        M----->W        M----->W
                    //              //
M----->W        M/ /            M/ /    W
                  /               /
M----->W        M/              M/      W
```

The letter M represents "man" and the letter W represents "woman". The arrows represent the relationship "loves".

Your diagram can have as many elements as you like (for example as many "M"'s and "W"'s) and as many interconnecting arrows as you think it needs. Some sentences may need more complicated diagrams than others, so take as long as you need to draw them. Please draw only one diagram for each sentence. You can keep the example diagrams with you during the experiment. Do you have any questions ?"

Subjects were tested either singly or in small groups. They were given as much time as they needed to complete the experimental task. This normally took about ten to fifteen minutes.

MEASURES.

The number of times subjects drew a converging or a diverging diagram was recorded for each condition.

RESULTS AND DISCUSSION.

Table 1, showing the overall results for Experiment 1 is included in Appendix 1(b). Samples of response sheets are included in Appendix 1(c). The results are set out in terms of the predictions made in the Introduction to Experiment 1.

DIAGRAM CHOICE.

Prediction : More diverging readings when the universal is first quantifier, more converging readings when the universal is second quantifier.

TABLE 1.1 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH WORD ORDER CONDITION.

	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	.47	.68	.57
DIVERGING	.50	.28	.39
MEANS	.48	.48	

Table 1.1 shows that more diverging readings were made when the universal was first quantifier, and more converging readings were made when the universal was second quantifier.

Prediction : More diverging readings in "every" sentences than in "all" sentences.

TABLE 1.2 MEAN NUMBER OF DIVERGING READINGS WITH "ALL" AND "EVERY".

	UNIVERSAL IST	UNIVERSAL 2ND	MEANS
ALL	.42	.17	.29
EVERY	.58	.39	.48
MEANS	.50	.28	

Table 1.2 shows that "every" causes more diverging readings than

"all", regardless of its position in a sentence.

Additional observations.

TABLE 1.3 MEAN NUMBER OF CONVERGING READINGS ACCORDING TO TYPE OF EXISTENTIAL.

	EXISTENTIAL 1ST			EXISTENTIAL 2ND			MEANS
	A	Some	Some (pl)	A	Some	Some (pl)	
ALL	.92	.67	.67	.75	.50	.50	.69
EVERY	.67	.42	.75	.50	.33	.25	.49
MEANS	.79	.54	.71	.62	.41	.37	

Table 1.3 indicates that overall "a" is more likely than "some" or "some (pl)" to induce the converging reading.

The word order prediction that when the universal occurs first more diverging readings will be made, and when the universal occurs second more converging readings will be made was supported by the data. Table 1.1 shows that when the universal occurs second the mean number of converging readings is .68, and the mean number of diverging readings is .28. This indicates that subjects are more likely to give the existential quantifier wide scope when it occurs at the beginning of a sentence. The prediction is also borne out when the universal is first quantifier, but the difference is not so striking. When the universal is first quantifier the mean number of diverging readings is .50, compared with .47 for converging readings.

Results suggest, therefore, that when people read a doubly-quantified sentence the quantifier they encounter first is more likely to receive wide scope. When the first quantifier is a universal the resulting interpretation is likely to be the diverging reading, and when the first quantifier is an existential the interpretation is more likely to be the converging reading.

The second prediction, that "every" will cause more diverging readings than "all", is supported by the data. Table 1.2 shows that regardless of its position in a sentence "every" induces more diverging readings than "all". This effect is especially noticeable when "every" and "all" occur in second position, after the existential quantifier. In this case the mean number of diverging readings with "every" is .39, and the mean number of diverging readings with "all" is .17. When the universal quantifiers occur in first position "every" causes a mean of .58 diverging readings compared to a mean of .42 diverging readings with "all".

Results suggest, therefore, that "every" is a more powerful quantifier than "all" since "every" is more likely to take wide scope wherever it occurs in a sentence. When the universal quantifiers occur in second position, a position less favoured for taking wide scope, "every" is much more likely than "all" to take wide scope. This finding suggests that "every" is not defeated by word order; even if "every" does not appear first in a sentence it can still take scope over the existential quantifier. The possibility of "all" taking wide scope in second position is much more slender.

Additional observations.

As a further observation the experiment examined whether more converging readings occurred with "a", "some" or "some(pl)". Table 1.3 indicates that overall "a" is more likely than "some" or "some(pl)" to cause the converging reading, regardless of where the existential quantifiers occur in a sentence. However, one exception to this is in "some(pl)....every" sentences (eg "Some pupils admire every teacher"). In this case "some(pl)" is more likely to take wide scope than some or "a".

On the face of it, Johnson-Laird's word order hypothesis is supported by the results of Experiment 1. However, the use of active sentences and their corresponding passives in Experiment 1 meant that in active sentences the existential always occurred as first quantifier and in passive sentences the universal always occurred as first quantifier. Thus, word order and the active / passive distinction were confounded in this experiment. It is difficult, therefore, to be certain whether word order or the active / passive variation caused the observed scope effects.

Results clearly indicated support for the second prediction, that "every" would induce more diverging readings than "all". However, the additional observation made with regard to the existential quantifiers is less clear cut. Overall, the pattern was for "a" to take wide scope more often than "some" or "some(pl)". This was not the case , however, with "some(pl)....every". It is difficult to account for this finding, since one would expect "some(pl)", indicating as it does more than one entity (eg "some pupils"), to result in the diverging reading, especially when coupled with "every". One possible explanation is that the content of a particular sentence caused this result, rather than the quantifiers used in the sentence.

One problem with Experiment 1 is that subjects saw only one example of each sentence type. Thus there was a danger that the content of the sentence might determine scope, and that the observed scope differences were due to content and not to word order or the type of quantifier used in the sentence. For example, one experimental sentence concerned Presidents and senators, eg:

"Some Presidents defeat every senator."

General knowledge provides the information that only one President is in office at any one time, and so this fact may have influenced subjects' scoping decisions.

Despite these problems in interpretation, the effects of word order and quantifier type examined in Experiment 1 merited further investigation.

EXPERIMENT 2.

INTRODUCTION.

Experiment 1 pointed towards support for Johnson-Laird's theory that word order determines scope assignments in doubly quantified sentences. Results from Experiment 1 also indicated differences in effect between "every" and "all", and between "a", "some" and "some(pl)".

In Experiment 1 subjects saw only one example of each sentence type and , therefore, one could not be sure whether the experimental variables of word order and quantifier type had caused scoping decisions, or whether something particular to a sentence, for example its content, had influenced interpretation. It was decided to increase the number of sentences subjects saw to 24 for Experiment 2. This meant that subjects encountered two sentences in each experimental condition, thereby decreasing the possibility that a particular feature of one sentence apart from those under investigation would influence subjects' scoping decisions. One group of sentences which were used in Experiment 1 was discarded in Experiment 2. These sentences referred to Presidents and senators, (eg "A President defeats all senators") and were not used in further experiments since it was felt that this sentence group might give unreliable results; subjects know that there is only one President at any given time.

As in Experiment 1 Experiment 2 investigated the effects of word order and quantifier type on the interpretation of doubly quantified sentences. Identical manipulations to those of Experiment 1 were used to investigate these factors.

Experiment 2 differed from Experiment 1 in that a microcomputer was used to record reading and drawing times for each experimental sentence. It was expected that by taking a measure of these times a more accurate picture of the factors determining scope could be gained. For example, reading times were examined on the assumption that slower reading times reflect a greater degree of complexity for the comprehension system. Sentences which consistently showed slower reading times would, it was assumed, be those in which it was more difficult to assign scope to a particular quantifier.

METHOD, EXPERIMENT 2.

SUBJECTS.

24 undergraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented on a 128K BBC microcomputer, model B+.

There were 12 experimental lists, each consisting of 24 sentences. The lists consisted of two sentences in each of the 12 experimental conditions which appear in the example sentences shown below :

Condition.	Example sentence.
Universal 2nd	
A...........all	1. A pupil admires all teachers.
A.........every	2. A pupil admires every teacher.
Some........all	3. Some pupil admires all teachers.
Some......every	4. Some pupil admires every teacher.
Some(pl)....all	5. Some pupils admire all teachers.
Some(pl)..every	6. Some pupils admire every teacher.
Universal 1st.	
All...........a	7. All teachers are admired by a pupil.
Every.........a	8. Every teacher is admired by a pupil.
All........some	9. All teachers are admired by some pupil.
Every......some	10. Every teacher is admired by some pupil.
All....some(pl)	11. All teachers are admired by some pupils.
Every..some(pl)	12. Every teacher is admired by some pupils.

The order of presentation of the sentences was randomised by the computer.

A complete list of the sentences used in this experiment can be found in Appendix 2(a).

DESIGN.

Experiment 2 investigated three factors:

1. Word order : Universal quantifier first vs Universal quantifier second
2. Type of Universal : All vs Every.
3. Type of existential : A vs Some.

These factors gave a total of 8 experimental conditions. However, the experimenter also included sentences in which "some" was followed by a plural noun phrase as in sentences 5,6,11 & 12 above. eg "Some pupils admire all teachers". This manipulation was included to investigate whether a difference in interpretation occurred between "some" followed by a singular noun phrase and "some" followed by a plural noun phrase. This gave a total of 12 experimental conditions. An example sentence for each condition can be found in the "Materials" section.

Twelve experimental lists were prepared. Every list consisted of twenty four sentences, two in each condition. Sentences were assigned to conditions by means of a matrix which ensured that each subject saw two example of each sentence type. There were 12 subjects.
The sentences were presented singly in normal case on the computer screen and s's were asked to draw a representation of the sentence using initial letters and arrows. eg:

converging diverging

The experimenter constructed a set of diagrams for the experimental sentences. The diagrams represented the converging and diverging reading for each sentence, and subjects' drawings were matched against these diagrams on completion of the experiment.

PROCEDURE.

Subjects were tested singly in a self-paced reading and drawing task. They were given a typed sheet of instructions which read as follows:
"I would like you to read the sentences which will appear on the computer screen. When you have read each sentence press the space bar to clear the screen. I would like you then to draw a diagram representing the sentence you have just read. Here is an example :

"Every man loves a woman."

```
M----->W         M----->W      M----->W
                     / /           / /
M----->W         M /  /        M /  /    W
                    /             /
M----->W         M /           M /       W
```

The letter M represents "man" and the letter W represents "woman". The arrows represent the relationship "loves".

You may find that there is more than one way to represent the sentence, as in the diagram above. If this happens draw the diagram that you prefer. Draw only one diagram for each sentence.
When you have completed the diagram press the space bar again to get the next sentence. There is a short practice sentence first. Do you have any questions ?"

The sentences were presented one at a time in normal case. Subjects were asked to press the space bar as soon as they had read the sentence and to begin drawing their diagram immediately. On completion of the diagram they were required to press the space bar again. This key press caused the next sentence to appear, and the sequence began again. When the final sentence had been read and the diagram drawn, the final key press caused the message "That's all thankyou. You can go now." to appear.

The experimenter remained with the subject for the duration of the practice list and was available to answer any questions. After the practice list was completed the subject was left alone to finish the experiment. Subjects normally took about twenty minutes to complete the experiment.

MEASURES.

A measure of the reading time for each sentence was taken by the BBC. Reading times were examined on the assumption that longer reading times reflect greater difficulty in the process of comprehension. The drawing time in each condition was also measured. The number of times subjects drew a converging or a diverging diagram was recorded in each condition.

RESULTS & DISCUSSION.

Table 2.1 and 2.2, showing the overall results for Experiment 2 are included in Appendix 2(b). Complete analysis of variance tables for this experiment are in Appendix 2(c) and 2(d).

In order to examine results statistically in an analysis of variance, both subjects and items (in this experiment sentences) must be regarded as random factors (Clark, 1973). This means that two separate F ratios must be computed; F1 treating subjects as a random factor and collapsing over sentences, and F2 treating sentences as a random factor and collapsing over subjects. Throughout the thesis both F1 and F2 will be reported and discussed where both are available.

F1 data only, (subject data), is available for Experiment 2 because there were insufficient scores available from the sentence data, (F2).

Results are organised in terms of the predictions made in the Introduction to this experiment.

DIAGRAM CHOICE.

Discussion of tables 2.3 and 2.4 is based on an analysis of variance shown in Appendix 2(c).

Prediction : More diverging readings when the universal is first quantifier, more converging readings when the universal is second quantifier.

TABLE 2.3 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH WORD ORDER CONDITION.

		UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING		2.87	4.46	3.66
DIVERGING		3.04	1.50	2.27
	MEANS	2.95	2.98	

Analysis of the data included in table 2.3 showed no effect of order, F1<1, df=1,11; p<.59. However, there was an interaction between order and diagram, F1=13.63, df=1,11; p<.004. More converging readings were made following universal second sentences, and more diverging diagrams were produced following universal first sentences.

Prediction : More diverging readings with "every" than with "all".

TABLE 2.4 MEAN NUMBER OF DIVERGING READINGS IN "EVERY" AND "ALL" SENTENCES.

		UNIVERSAL 1ST	UNIVERSAL 2nd	MEANS
ALL		2.50	1.33	1.91
EVERY		3.58	1.67	2.62
	MEANS	3.04	1.50	

Analysis of the data included in table 2.4 showed no effect of type of universal, F1<1, df=1,11; p<.59

Additional observations.

TABLE 2.5 MEAN NUMBER OF CONVERGING READINGS ACCORDING TO TYPE OF EXISTENTIAL.

	EXISTENTIAL 1ST			EXISTENTIAL 2ND			MEANS
	A	Some	Some(pl)	A	Some	Some(pl)	
ALL	1.75	1.67	1.25	1.42	1.00	0.92	1.33
EVERY	1.60	1.25	1.42	1.00	0.58	0.75	1.10
MEANS	1.67	1.46	1.33	1.21	0.79	0.83	

Overall, "a" took wide scope more often than "some" or "some(pl)", as indicated by inspection of Table 2.5.

RESPONSE TIME.

A further observation examined reading and drawing times for each condition. However, it was necessary to sum reading and drawing times in this experiment because subjects often forgot to press the space bar after reading the experimental sentence and before beginning to draw their diagram. This resulted in implausibly long reading times for some subjects, so it was not possible to gain separate measures of reading and drawing times. The sum of reading and drawing time in each condition is referred to as Response Time.

TABLE 2.6 MEAN RESPONSE TIME (MSECS) FOR CONVERGING AND DIVERGING READINGS IN EACH CONDITION.

	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	26412	25270	25706
DIVERGING	29540	27988	28764
MEANS	27841	26629	

Table 2.6 indicates that overall converging readings are made more quickly than diverging readings. However, an analysis of variance comparing response times for converging readings and response time for diverging readings was not significant ($F1=2.51$, $df=1,11$; $p<.138$).

Table 2.6 also shows that sentences where the universal occurred as second quantifier were read more quickly than sentences where the universal was first quantifier. An analysis of variance compared response times for universal first and universal second sentences, and for converging and diverging readings. There was no effect of word order (universal first vs universal second), $F1=1.46$, $df=1,5$; $p<.28$, and no effect of reading (converging vs diverging) $F=1.73$, $df=1,5$; $p<.24$)

Results from Experiment 2 support Johnson-Laird's prediction that word order determines quantifier scope. He predicts that when the universal quantifier occurs first more diverging readings will result, and when the universal occurs second more converging readings will result. Table 2.3 indicates that more converging readings result when the existential is first (ie universal second sentences), and more diverging readings result when the universal is first. Although the analysis indicated that order was not significant a significant interaction was found between order and diagram, in the predicted direction. This supports the word order hypothesis.

However, it is difficult to draw any firm conclusions in accounting for this finding, since the strategy of using active sentences and their correlative passives meant that in actives the universal was always second quantifier and in passives the universal was always first quantifier. This led to word order being confounded with the active / passive variable. It is not clear, therefore, whether observed scope effects are due to word order or voice.

Turning now to the second prediction, that "every" will cause more diverging readings than "all". Results as illustrated in Table 2.4 show support for this prediction, though the analysis was not significant. Regardless of its position in a sentence "every" induces more diverging readings than "all". This result suggests that "every" is a more powerful quantifier than "all".

Additional observations.

The data was examined to see if the existential quantifiers "a" , "some" , and "some(pl)" had different scope effects. Table 2.5 shows that overall "a" is more likely than "some" and "some(pl)" to result in the converging reading.

There is a suggestion in the data that sentences with the universal second are read more quickly than universal first sentences. Table 2.6 shows that the mean response time for universal second sentences is 26629 msecs, compared with 27841 msecs for universal first sentences. This suggests that universal first sentences are more difficult to comprehend, but the data is not statistically significant. Again, the dat may be reflecting the effect of voice and not word order; universal first sentences were always actives, and universal second sentences were always passives. Moreover, the data may be unreliable because it is based on the sum of both reading and drawing times. A measure of reading time alone would present a more accurate picture, though the problem of word order and voice being confounded would remain.

To summarise then, the data broadly supported Johnson-Laird's word order hypothesis.However it should be noted that voice and word order were confounded in Experiment 2. The prediction that "every" results in more diverging readings than "all" was supported. The pattern regarding the range of effect of the existential suggested that "a" was more likely to result in the converging reading than the other existentials. Finally, there was some suggestion that existential first sentences produced shorter reading times, prompting the idea that they were easier to comprehend, but the data was marred by the fact that reading and drawing times were of necessity added together. A clearer picture could be provided by examining reading time alone.

1EXPERIMENT 3.

INTRODUCTION

Experiments 1 & 2 had provided some suppport for the theory that word order determines quantifier scope. However, in the previous experiments word order, ie universal first vs universal second, had been confounded with voice, so that one could not be certain whether word order or the active / passive difference had caused the observed results. In order to investigate word order in Experiment 3, therefore, it was decided to use only active sentences and to manipulate word order by alternating the position of the universal as shown in the examples below:

Universal 1st	Universal 2nd
All boys befriend a girl.	A boy befriends all girls.
Every boy befriends a girl.	A boy befriends every girl.

Experiment 3 also used the same universal and multiple quantifiers as th previous two experiments. Predictions for Experiment 3 are the same as those for Experiments 1 & 2.

In Experiment 2 it had not been possible to get separate measures of reading and drawing times. The instructions given to subjects in Experiment 3 were improved to alleviate this problem.

METHOD, EXPERIMENT 3.

SUBJECTS.

Twelve undergraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented using a 128K BBC microcomputer , model B+ . There were 12 experimental lists, each consisting of 24 sentences. Each list carried two examples of the twelve experimental conditions detailed in the example sentences below.

Condition.	Example sentence.
Universal 2nd	
A...........all	1. A pupil admires all teachers.
A.........every	2. A pupil admires every teacher.
Some........all	3. Some pupil admires all teachers.
Some......every	4. Some pupil admires every teacher.
Some(pl)....all	5. Some pupils admire all teachers.
Some(pl)..every	6. Some pupils admire every teacher.
Universal 1st.	
All...........a	7. All pupils admire a teacher.
Every.........a	8. Every pupil admires a teacher.
All........some	9. All pupils admire some teacher.
Every......some	10. Every pupil admires some teacher.
All....some(pl)	11. All pupils admire some teachers.
Every..some(pl)	12. Every pupil admires some teachers.

The order of presentation of the sentences was randomised by the computer.

A complete list of the sentences used in this experiment can be found in Appendix 3(a).

<u>DESIGN.</u>

Experiment 3 investigated three factors:

1. Word order : Universal quantifier first vs Universal quantifier second.

2. Type of Universal : All vs Every.

3. Type of existential : A vs Some.

These factors gave a total of 8 experimental conditions. However, the experimenter also included sentences in which "some" was followed by a plural noun phrase as in sentences 5,6,11 & 12 above, eg "Some pupils admire all teachers". This manipulation was included to investigate whether a difference in interpretation occurred between "some" followed by a singular noun phrase and "some" followed by a plural noun phrase. This gave a total of 12 experimental conditions. An example sentence for each condition can be found in the "Materials" section.

Twelve experimental lists were prepared. Every list consisted of twenty four sentences, two in each condition. Sentences were assigned to conditions by means of a matrix which ensured that each subject saw two example of each sentence type. There were 12 subjects.

The sentences were presented singly in normal case on the computer screen and s's were asked to draw a representation of the sentence using initial letters and arrows. eg:

```
a-------b          a-------b

a       b          a-------b

a       b          a-------b

converging         diverging
```

The experimenter constructed a set of diagrams for the experimental sentences. The diagrams represented the converging and diverging reading for each sentence, and subjects' drawings were matched against these diagrams on completion of the experiment.

PROCEDURE.

Subjects were tested singly in a self-paced reading and drawing task. They were given a typed sheet of instructions which read as follows:

"I would like you to read the sentences which will appear on the screen. When you have read each sentence press the space bar to clear the screen. I would like you then to draw a diagram representing the sentence you have just read. Here is an example :

"Every man loves a woman."

```
M----->W        M----->W       M----->W
                    / /            / /
M----->W        M  / /         M  / /     W
                  /              /
M----->W        M/             M/         W
```

The letter M represents "man" and the letter W represents "woman". The arrows represent the relationship "loves".

You may find that there is more than one way to represent the sentence, as in the diagram above. If this happens draw the diagram that you prefer. Draw only one diagram for each sentence.

When you have completed the diagram press the space bar again to get the next sentence. There is a short practice sentence first. Do you have any questions ?"

Subjects were given extra verbal encouragement by the experimenter to press the space bar as soon as they had read and understood each sentence and before they began to draw a diagram. This was to avoid the problem of having to combine reading and drawing times for all subjects to compensate for those occasions when subjects began to draw their diagram without pressing the space bar first. When this happened reading times were apparently very long and drawing times short.

The sentences were presented one at a time in normal case. Subjects were asked to press the space bar as soon as they had read the sentence and to begin drawing their diagram immediately. On completion of the diagram they were required to press the space bar again. This key press caused the next sentence to appear, and the sequence began again. When the final sentence had been read and the diagram drawn, the final key press caused the message "That's all thankyou. You can go now." to appear.

The experimenter remained with the subject for the duration of the practice list and was available to answer any questions. After the practice list was completed the subject was left alone to finish the experiment. Subjects normally took about twenty minutes to complete the experiment.

MEASURES.

A measure of the reading time for each sentence was taken by the BBC. Reading times were examined on the assumption that longer reading times reflect greater difficulty in the process of comprehension. The drawing time in each condition was also measured. The number of times subjects drew a converging or a diverging diagram was recorded in each condition.

RESULTS & DISCUSSION.

Overall results for Experiment 3 are included in Appendix 3(b). Complete analysis of variance tables for this experiment are in Appendices 3(c)-3(e).

Results are set out in terms of the predictions made in the introduction to this experiment.

F2 data , (sentence data) is not available for this experiment since there were insufficient scores.

DIAGRAM CHOICE.

Discussion of tables 3.3 and 3.4 is based on an analysis of variance shown in Appendix 3(c).

Prediction : More diverging readings when the universal is first quantifier; more converging readings when the universal is second quantifier.

TABLE 3.3 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH WORD ORDER CONDITION.

	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	2.46	4.96	3.71
DIVERGING	3.50	1.00	2.25
MEANS	2.98	2.98	

Table 3.3 shows that in universal second sentences there was a marked tendency for subjects to make the converging reading. An analysis of variance on the data indicated an interaction between order and diagram, $F1=48.17$, $df=1,11$; $p<.00009$. More converging readings were made when the universal was second quantifier.

Prediction : More diverging readings with "every" than with "all".

TABLE 3.4 MEAN NUMBER OF DIVERGING READINGS WITH "ALL" AND "EVERY".

	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
ALL	2.92	0.75	1.83
EVERY	4.08	1.25	2.66
MEANS	3.50	1.00	

Table 3.4 indicates that regardless of position "every" induces more diverging readings than "all". An analysis of variance on this data showed an interaction between type of universal and diagram, $F1=12.57$, $df=1,11$; $p<.005$. Fewer diverging readings were produced following "all" sentences.

Additional observations.

TABLE 3.5 MEAN NUMBER OF CONVERGING READINGS ACCORDING TO TYPE OF EXISTENTIAL

Sentence type Existential	EXISTENTIAL 1ST	EXISTENTIAL 2ND	MEANS
A	3.16	1.92	2.54
Some	3.00	1.92	2.46
Some (pl)	3.75	1.42	2.58
MEANS	3.30	1.75	

An analysis of variance on the data shown in table 3.5 indicated that type of existential was not significant, $F1=1$, $df=1,11$; $p<.34$. However the analysis indicated an interaction between order and diagram, $F1=48.58$, $df=1,11$; $p<.00009$. When the existential occurred as first quantifier more converging than diverging readings were made. The analysis also showed a three way interaction between order, existential and diagram, $F1=5.75$, $df=1,11$; $p<.0098$.

RESPONSE TIME.

A further observation examined reading and drawing times for each condition. However, it was necessary to sum reading and drawing times in this experiment because subjects often forgot to press the space bar after reading the experimental sentence and before beginning to draw their diagram. This resulted in implausibly long reading times for some subjects, so it was not possible to gain separate measures of reading and drawing times. The sum of reading and drawing time in each condition is referred to as Response Time.

TABLE 3.6 MEAN RESPONSE TIME (READING AND DRAWING TIME) (MSECS) FOR CONVERGING AND DIVERGING READINGS IN EACH CONDITION.

	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	22512	23406	22959
DIVERGING	25007	27829	26418
MEANS	23759	25617	

Table 3.6 indicates that when converging readings are made, the doubly quantified sentence is read faster than when diverging readings are made. An analysis of variance on this data was significant, ($F1=4.64$, $df=1,11$; $p<.05$). A second analysis of variance was carried out on the data to compare the response time for sentences with the universal either in first or in second position, taking into account whether subjects subsequently made a converging or a diverging reading. The results of this analysis were not significant. There was no effect of reading, converging or diverging, ($F1=2.57$, $df=1,5$, $p<.17$), and no effect of quantifier order , universal first or universal second, ($F1=1.31$, $df=1,5$; $p<.30$). A third analysis of variance examined those cases where a converging reading was made and compared response times

for the first sentence in each condition. This data was not significant, $F1<1$, $df=11,22$; $p<.88$.

Results from Experiment 3 support Johnson-Laird's word order hypothesis. There were more diverging readings when the universal was first quantifier, and more converging readings when the universal was second quantifier. Since all the sentences used in this experiment were actives, voice (ie active or passive) cannot be causing the differences in scope evident between word order conditions.

It was also apparent from the results of Experiment 3 that "every" consistently caused more diverging readings than "all", regardless of its position in a sentence. This finding reinforces Ioup and Fodor's view that "every" is a more powerful quantifier than "all". Analysis of the data also showed that more diverging readings resulted when "every" or "all" occurred as first quantifier in a sentence. This finding provides further support for Johnson-Laird's word order hypothesis. However there was no significant interaction between word order and type of universal.

Additional observations.

Examination of the data regarding differences in scope effects between the existential quantifiers "a", "some" and "some(pl)" provided a confusing picture. Overall "a" was better at inducing the converging reading than "some" and "some(pl)", with the exception of those sentences where "some(pl)" occurred first, eg:

"Some pupils admire all teachers."

"Some pupils admire every teacher."

Here "some(pl)" was more successful at inducing the converging reading than either "a" or "some". This pattern was similar to that found in Experiment 1, but dissimilar to Experiment 2. This point will be reviewed in the Discussion of Experiments 1, 2 & 3.

Data from response times showed that subjects responded to the doubly quantified sentences faster if they subsequently made a converging reading. It is possible that subjects find the converging reading the easiest to compute; a sentence which induces the diverging reading takes longer to read and one would hypothesise that the extra reading time needed for such sentences reflects their complexity for the comprehension system. However, it is not possible to be precise on this point because the response time for this experiment is a composite of reading time and drawing time, as in Experiment 2. This means that one does not get an accurate picture of the steps subjects go through in their interpretation of doubly quantified sentences. Separate measures might have highlighted areas of interest.

An analysis of variance comparing response time for the doubly quantified sentence in both word order conditions, and taking into account the type of reading made, showed no effect of the reading made (ie the diagram subjects drew). Again, the difficulty in explaining this result lies in the fact that the reading and drawing times were added together. One would expect that a sentence inducing the converging reading would facilitate a shorter drawing time for the converging diagram, while a sentence inducing the diverging reading would facilitate a shorter drawing time for the diverging diagram. Sentences in which it was difficult to decide on a reading should have longer reading times. Without a separate measure of reading and drawing time it is not possible to comment further on this point. The analysis also indicated that there was no effect of quantifier order ; both these results support the findings of Experiment 2.

DISCUSSION OF EXPERIMENTS 1, 2 & 3.

The word order prediction associated with Johnson-Laird, that when the universal occurs first more diverging readings will result, and when the universal occurs second more converging readings will result, was supported by results from Experiments 1, 2 & 3.

Experiments 1, 2 & 3 both showed a more marked word order effect when the universal quantifier occurred in second position. In this case many more converging readings resulted than diverging readings. One cannot be certain whether results from Experiments 1 & 2 are due to the word order difference or to the active / passive difference, since these two variables were confounded. Experiment 3 used only active sentences and should, therefore, provide a more comprehensible set of data. Analysis of this data showed a significant effect of word order, in support of Johnson-Laird's hypothesis. There were more converging readings when the universal was second quantifier, and more diverging readings when the universal was first quantifier.

Results from the first three experiments suggest, therefore, that the quantifier people encounter first in a sentence is the one most likely to be given wide scope. This finding is in agreement with Fodor's prediction.

Both Fodor and Ioup theorise that "every" is more likely than "all" to take wide scope wherever it occurs in a sentence. Fodor believes that "all" is the "least hungry" (Fodor,1975) of the multiple quantifiers, and Ioup places "all" below "each" and "every" on her hierarchy of those quantifiers with the greatest inherent tendency towards highest scope. Results from all three experiments so far described bore out this prediction. "Every" consistently caused more diverging readings than "all" regardless of its position in a sentence, but in all three experiments the effect was especially striking when "all" and "every" occurred as second quantifiers. In this position one would expect more converging readings for the sentence, and in fact this expectation was supported. However, even in this inferior position "every" caused more diverging readings than "all".

This finding suggests that word order is not the only factor in determining quantifier scope. If it were then one would expect that a sentence beginning with a universal would result in the diverging reading, and one beginning with the existential would result in the converging reading. Results from the word order data have shown that this is not the case, and the results found with "all" and "every" underline this. It seems likely that some characteristic of the quantifiers themselves also plays a role in determining quantifier scope. For example, "all" and "every" identify essentially the same set, but they appear to have very different effects on scope. One possible reason for this is that "every" seems to specify more clearly than "all" that each member of a particular set took part individually in some action; "all" on the other hand seems to refer to the set as a single entity; a group. The difference is perhaps best illustrated by the following sentences:

?? Every soldier surrounded the fort.

All the soldiers surrounded the fort.

(Fodor, 1975)

Fodor believes that "every" needs to take scope over at least one constituent in a sentence other than the nominal it is associated with, (the requirement is more strict with "each") , while there is no such necessity for "all". Fodor states that "each" can extend its scope further in either direction in a sentence than the other multiple quantifiers; results from Experiments 1,2 & 3 suggest that "every" is better than "all" at extending its scope in a similar fashion.

As an additional observation, Experiments 1 , 2 & 3 investigated which existential quantifier was most likely to cause the converging reading.In general results showed that "a" was more likely than "some" and "some(pl)" to cause the converging reading. Presumably this is because "a" specifies very clearly in a sentence that only one entity is involved in a relationship or activity. (Again it must be noted that in Experiments 1 & 2 "a" always occurred as first quantifier in active sentences only, and so care must be taken when attempting to draw conclusions from the data.)

However, despite the general tendency for "a" to take wide scope over the other existential quantifiers, there were some exceptions to this trend. In Experiment 1 more converging readings resulted with the "some(pl)...every" combination of quantifiers , eg "Some pupils admire every teacher". This was not thought to be a reliable result because subjects saw only one sentence of each type and, therefore, something particular about the sentence could have given this result.

In Experiment 3, despite the overall ability of "a" to take wide scope, sentences in which "some(pl)" occurred first were more successful at inducing the converging reading. It is difficult to decide what is happening in these exceptional cases. In general "a" fulfils its potential as a clearly existential quantifier and induces converging readings; one would not expect "some(pl)" to act in the same way, especially in sentences containing "every" as a first quantifier as in Experiment 2. Results show that "every" is a powerful multiple quantifier and should, therefore, take wide scope and induce the diverging reading. In those cases where "some(pl)" exceeds the capacity of "a" to induce converging readings the plural noun phrase seems to have increased the chance that subjects made the converging reading , perhaps signalling more strongly than "a" that the sentence is referring to one entity in particular.

One factor which does become evident from the investigation into the effects of universal quantifiers is that in each experiment more converging readings occur in "all" sentences than in "every" sentences. This confirms the earlier finding that "all" is less powerful a multiple quantifier than "every" since it is less likely to take scope over the existential and induce the diverging reading.

Finally, Experiments 2 & 3 examined the reponse time in each experimental condition. In Experiment 2 it was found that response time was faster for universal second sentences, though the data was not significant. Experiment 2 utilised both active and passive sentences, however, and in active sentences the universal was always second quantifier. It seems likely, therefore, that this result is reflecting longer response times for passives rather than actives, and not illustrating a word order difference, but one cannot decide with any degree of certainty between the two factors. In Experiment 3, where only active sentences were used, response time was faster for universal first sentences, but the data was not significant. One possible explanation for this is that the multiple quantifiers are less ambiguous and, therefore, less complex for the comprehension system. To paraphrase Fodor, subjects may be making use of a "ditto" strategy, ie setting up only a skeletal representation of the sentence which can be modified later if necessary. For example,the representation for "Every pupil admires a teacher" could begin as:

p-------t

p-- ditto

p--

and be changed later if required.

However, results from Experiment 3 also indicate that when the converging reading is made response time is significantly faster than when the diverging reading is made. This may indicate that the converging reading is easiest to compute, but it is not possible to make strong claims about this; response times are the sum of reading and drawing times and as such may simply reflect the fact that subjects take longer to draw a diagram representing the diverging reading, which has more elements than a diagram representing the converging reading.

To summarise then, there is some support for Johnson-Laird's and Fodor's word order hypothesis in Experiments 1, 2 & 3. There is ample support for Fodor's and Ioup's claim that "every" is a more dominant quantifier than "all". The picture concerning the existential quantifiers is less clear, but it seems likely that the inherent characteristics of individual quantifiers have a part in determining scope. Response time data suggests that the converging reading is the simplest, but methodological problems preclude predictions from this data.

The following set of experiments seeks to provide a more coherent account of quantifier scope. They use active and passive sentences in both word order conditions so that an investigation into voice and word order can be made. Sentences and diagrams are presented on a computer screen so that it is possible to measure accurately the time taken to read the sentence and the time taken to make a decision about the diagram.

CHAPTER 3.

SUBJECT / PREDICATE EVALUATIONS.

EXPERIMENT 4.

INTRODUCTON.

Experiments 1, 2 & 3 examined drawings generated by the subjects themselves. The drawings were later classified into converging and diverging readings. However, the first set of experiments did not provide sufficient detail about the stages of the scope assignment process. For example, it was not possible to get an accurate picture of the reading time for the first sentence, nor was there a record of how long subjects took to think about their diagram and to draw it.

The "subject / predicate evaluation" experiments were designed to take account of these problems. In Experiment 4 subjects were presented with a doubly quantified sentence on a microcomputer screen just as in Experiments 2 and 3. However ,immediately after the presentation of the sentence they saw two diagrams illustrating the possible readings (ie converging or diverging) for the sentence they had just seen. For example, the sentence :

"All boys befriend a girl."

would be followed by these diagrams :

```
b------g          b-------g
     / /
b/  /             b-------g
   /
b/                b-------g

converging        diverging
```

Subjects had to choose the diagram which they considered appropriate to the sentence. The design of the experiment ensured that a measure could be taken of the reading time for the doubly quantified sentence, the time subjects took to evaluate the diagram, and the type of diagram they chose. These measures would , therefore , provide a more accurate picture of the comprehension process involved in disambiguating doubly quantified sentences.

The aim of Experiment 4 was to examine the factors affecting the interpretation of quantified sentences. The interpretation of quantified sentences was investigated by manipulating two variables, word order and quantifier type. Word order was manipulated by alternating the position of the universal and existential as in the examples below:

Universal 1st	Universal 2nd
"All boys befriend a girl ."	"A boy befriends all girls."
"Every boy befriends a girl."	"A boy befriends every girl."

The effect of quantifier type was examined by including both universal and existential quantifiers. There were two universal quantifiers, "all" and "every", and two existential quantifiers, "a" and "some" followed by a singular noun phrase,eg "some pupil". This gave sentences such as :

"A boy befriends all girls."

"A boy befriends every girl."

"Some boy befriends all girls."

"Some boy befriends every girl."

together with their corresponding universal second sentences.

There are a number of predictions which arise from these

manipulations. Firstly, in the case of word order Johnson-Laird would predict that when the universal quantifier occurs first, more diverging than converging readings will result, and when the universal occurs second more converging than diverging readings will result. Diverging readings are those in which the universal quantifier takes wide scope and converging readings are those in which the existential takes wide scope. Fodor also believes that the earlier a quantifier occurs in a sentence the more likely it is to take wide scope.
In the case of quantifier type, in particular type of universal, the prediction is as follows. Ioup argues that "every" tends to take highest scope regardless of where it occurs in a sentence, and both Ioup and Fodor believe that "every" is more likely to take wide scope than "all" is. One would, therefore, predict that sentences containing "every" will result in more diverging readings than sentences containing "all". The tendency for "every" to take wide scope may interact with word order so that the effect is greater when "every" is in first position. Also, the experiment tested whether more converging readings were made with "a" or "some".

Reading times were examined on the assumption that longer reading times reflected greater complexity for the comprehension system; sentences which resulted in longer reading times would be those in which the ambiguity was greatest . Evaluation times for the diagrams were examined on the assumption that shorter evaluation times would reflect the facilitation effect of experimental conditions, ie subjects would evaluate a diagram consistent with their model of the doubly quantified sentence more quickly than one which was inconsistent with the model. For example, a short evaluation time for a particular diagram should reflect the ease with which that diagram could be mapped on to the experimental sentence.

All the experimental sentences contained concrete nouns and were chosen so as to reduce the possiblity that subjects would have strong expectations about their content. The lexical material varied across sentences.

METHOD, EXPERIMENT 4.

SUBJECTS.

Ten undergraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented using a BBC Master series microcomputer. There were two experimental lists, each consisting of 40 sentences. Below are examples of the sentences seen by subjects.

Condition.	Example sentence.
Universal 2nd	
A...........all	1. A pupil admires all teachers.
A.........every	2. A pupil admires every teacher.
Some........all	3. Some pupil admires all teachers.
Some......every	4. Some pupil admires every teacher.
Universal 1st.	
All...........a	5. All pupils admire a teacher.
Every.........a	6. Every pupil admires a teacher.
All........some	7. All pupils admire some teacher.
Every......some	8. Every pupil admires some teacher.

The order of presentation of the sentences was randomised by the computer.

A complete list of experimental sentences can be found in Appendix 4(a).

DESIGN.

Experiment 4 investigated three factors:

1. Word order : Universal quantifier 1st vs Universal quantifier 2nd.
2. Type of Universal : All vs Every.
3. Type of Existential : A vs Some.

This gave a total of 8 conditions. Two lists, List A and List B were prepared. Both lists consisted of 40 sentences . The order of sentences was as follows :

LIST A		LIST B	
Sentences 1---5	A.........All	Sentences 1---5	All.........A
6--10	All.........A	6--10	A.........All
11-15	A.......Every	11-15	Every.......A
16-20	Every.......A	16-20	A.......Every
21-25	Some......All	21-25	All......Some
26-30	All......Some	26-30	Some......All
31-35	Some....Every	31-35	Every....Some
36-40	Every....Some	36-40	Some....Every

Odd numbered subjects saw List A and even numbered subjects saw List B. Subjects saw five sentences in each experimental condition.The order of presentation of sentences was randomised on each list by the microcomputer.

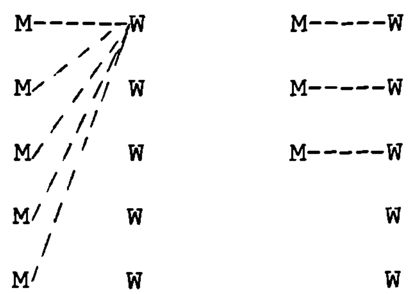
PROCEDURE.

Subjects were tested singly in a self-paced reading and evaluation task. They were given a typed sheet of instructions which read as follows:

"A sentence will appear on the computer screen. I would like you to read this sentence and press the space bar as soon as you have done so. The sentence will be followed by two diagrams, both of which show possible ways to represent the sentence. For example, a sentence like:

"Every man loves some woman".

will be followed by diagrams like this:



Please choose the diagram which is most appropriate to the sentence you have just read. If you think the left-hand diagram is the most suitable one, press the key marked "LEFT". If you think the right-hand diagram is the most suitable one press the key marked "RIGHT".
Work your way through the experiment as quickly as you can but make sure you understand the sentences you read. There are 40 sentences in all and you will have 8 practice sentences first".

The sentences were presented one at a time in normal case. Subjects were asked to press the space bar as soon as they had read the sentence. This key press removed the sentence from the screen and the two diagrams, representing the converging and diverging interpretations for each sentence appeared on the screen. Both diagram types appeared randomly at the left and right sides of the screen.

Subjects then had to press a key marked "LEFT" if they chose the diagram which appeared on the left-hand side of the screen, or a key marked "RIGHT" if they chose the diagram which appeared at the right hand side of the screen. The key marked "LEFT" was at the letter "E" position on the keyboard (ie at the left-hand side of the keyboard), and the key marked "RIGHT" was at the letter "I" position on the keyboard, (ie at the right-hand side of the keyboard). This key press removed the diagrams from the screen and the next experimental sentence appeared.

Subjects were advised to keep their left hand positioned over the "LEFT" key and their right hand positioned over the "RIGHT" key. They were also advised to use their thumbs to press the space bar. This method facilitated speed of response. When the final sentence had been read and the appropriate diagram chosen the final key press caused the message "That's all thankyou. You can go now." to appear.
The experimenter remained with the subject for the duration of the practice list and was available to answer any questions. After the practice list was completed the subject was left alone to finish the experiment. Subjects normally took about ten to fifteen minutes to complete the experiment.

MEASURES.

The reading times for sentences in each experimental condition were measured. A measure of the time taken to evaluate each pair of diagrams was taken, and the number of times subjects chose a converging or a diverging diagram in each condition was recorded.

RESULTS AND DISCUSSION.

Appendix 4(b) contains overall results for reading times, evaluation times and mean scores for converging and diverging diagrams for Experiment 4. Occasionally missing scores occurred in the data due to both examples of a diagram type being rejected. These missing scores were removed from the reading and evaluation time data before analyses were carried out, and so the results are attenuated because of this. Diagram choice analyses refer to data from both converging and diverging diagrams. The analysis of variance tables for this experiment are in Appendices 4(c) to 4(l).

DIAGRAM CHOICE.

Prediction : more diverging readings when the universal is first quantifier, more converging readings when the universal is second quantifier.

Scores were calculated a follows; choice of a converging diagram scored 1, and choice of a diverging diagram scored 0. Thus in the Tables below the closer the mean score is to 5 the more likely it is that a converging diagram was chosen.

TABLE 4.3. MEAN NUMBER OF TIMES CONVERGING AND DIVERGING DIAGRAMS CHOSEN IN EACH WORD ORDER CONDITION. (scores out of 5, CONVERGING=1, DIVERGING=0).

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type			
CONVERGING	3.3	3.5	3.4
DIVERGING	1.7	1.4	1.5
MEANS	2.5	2.4	

An analysis of variance compared the scores for converging and diverging diagrams chosen by subjects in each condition. There were no significant results.

Prediction : more diverging readings with "every" than with "all".

TABLE 4.4 MEAN NUMBER OF DIVERGING DIAGRAMS CHOSEN ACCORDING TO TYPE OF UNIVERSAL. (SCORES OUT OF 5; CONVERGING=1, DIVERGING=0.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
All	1.8	1.5	1.6
Every	1.1	1.8	1.4
MEANS	1.4	1.6	

Analysis of the data showed no significant results.

Additional observations.

TABLE 4.5 MEAN NUMBER OF CONVERGING DIAGRAMS CHOSEN ACCORDING TO TYPE OF EXISTENTIAL.(SCORES OUT OF 5; CONVERGING=1, DIVERGING=0).

Sentence Type	EXISTENTIAL 1ST		EXISTENTIAL 2ND		MEANS
	A	Some	A	Some	
ALL	3.2	3.2	3.8	3.2	3.3
EVERY	4.2	3.7	3.3	3.0	3.5
MEANS	3.7	3.5	3.5	3.1	

Table 4.5 shows that overall "a" was more likely than "some"to induce the converging reading but an analysis indicated that there were no significant results.

READING TIMES.

TABLE 4.6 MEAN READING TIMES (MSECS) FOR DOUBLY QUANTIFIED SENTENCE.

Sentence Type		UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type				
CONVERGING		2022	1884	1953
DIVERGING		2139	2155	2147
	MEANS	2080	2019	

Inspection of Table 4.6 indicates that overall reading times were faster when the universal quantifier occurred last. (Please note that reading times are contingent on subsequent diagram choice.) The data for "all" and "every" sentences was analysed separately. The analyses for "all" sentences are shown in Appendix 4(e) and the analyses for "every" sentences are shown in Appendix 4(f).

TABLE 4.7 MEAN READING TIMES (MSECS) FOR "ALL" SENTENCES.

Sentence Type		UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type				
CONVERGING		2247	1963	1963
DIVERGING		2515	2276	2276
	MEANS	2381	2119	

An analysis of variance compared reading times in "a / all" sentences in both word orders. An effect of order was found on F2 only; $F2=6.75$, $df=1.6$; $p<.04$; $F1=4.28$, $df=1,4$; $p <. 107$.Reading time was faster when "all" was second quantifier.

TABLE 4.8 MEAN READING TIMES (MSECS) FOR "EVERY" SENTENCES.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type			
CONVERGING	1797	1805	1801
DIVERGING	1762	2034	1898
MEANS	1779	1919	

There were no significant results for "every" sentences.

EVALUATION TIMES.

TABLE 4.9 MEAN EVALUATION TIME (MSECS) FOR DIAGRAMS IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type			
CONVERGING	2070	1876	1973
DIVERGING	1586	1547	1566
MEANS	1828	1711	

An analysis of variance compared evaluation times following "a / every" sentences in both word orders. There was an interaction, on F2 only, between diagram type and word order. When the converging diagram was chosen, evaluation time was faster when "a" occurred as first quantifier. When the diverging diagram was chosen, evaluation time was faster when "a" occurred as second quantifier ($F2=7.17$, $df=1,6$, $p <.04$, $F1<1$, $df=1,4$) . There were no significant results for any of the other quantifier combinations.

The hypothesis that more diverging readings would result when the universal was first quantifier was not supported by the data. There were more converging than diverging readings in both word order conditions, and the data showed no effect of position of universal. This is a surprising result, given that results from Experiments 1, 2, & 3 on the whole supported the word order hypothesis. One possible reason for the results found in Experiment 4 is that subjects find the converging diagram easier to deconstruct than the diverging diagram. Although in principle both diagram types are equally acceptable interpretations of the experimental sentences, (though the experimenter expects that the variables of word order and quantifier type will have an effect on scope preferences) the converging diagram may simply be easier to understand than the diverging one. Subjects may accept this diagram type because it is the easiest option and , therefore, less costly in terms of psychological effort.

The second prediction, that "every" will induce more diverging readings than "all" was supported only when "every" occurred as second quantifier. In fact the experimenter noticed an effect of task here, since in the drawing tasks "every" was more likely to take wide scope than "all" regardless of its position in a sentence.

Additional observations.

As an additional observation Experiment 4 investigated whether "a" or "some" was better at inducing the converging reading. Results indicated without exception that sentences containing "a" were more likely to induce the converging reading than sentences containing "some", though results were not significant. Again an effect of task was apparent here, since in the drawing experiments there were exceptions, notably "some...every" and "every...some(pl)" sentences , to the tendency for "a" to induce the converging reading.

Turning now to Reading Time data for the doubly quantified sentence. Overall it was found that reading times for the sentences were faster when the universal occurred as last quantifier. Analyses of variance, however, showed no effect of word order and no effect of subsequent diagram choice, except in "a...all" sentences where on F2 only it was found that when the converging diagram was chosen reading time was faster when "a" was first quantifier, and when the diverging reading was chosen reading time was faster when"a" was second quantifier. There are two possible interpretations of this result. Either scope has been assigned and is not affected by the experimental manipulation or scope has not been assigned at all. It is not possible to distinguish between these two interpretations on the basis of present data.

There was some support for the word order hypothesis in the evaluation time data . It was found that in "a...every" sentences there was an interaction between diagram type and word order. When the converging diagram was chosen, the time subjects spent evaluating the diagram was shorter when "a" was first quantifier. Conversely when the diverging diagram was chosen the time subjects spent evaluating the diagram was shorter when "a" was second quantifier. However, other quantifier pairs did not show this pattern, and indeed an analysis concentrating only on those cases where a converging diagram was chosen indicated that evaluation time was faster when the existential occurred as second quantifier.

One possible reason for the null results in this experiment is that the data was limited because of missing scores. Missing scores resulted when people rejected both examples of a diagram type for a particular sentence type. Because of its limitations the data may not be sufficiently reliable.

Experiment 4 investigated the effect of the universal quantifiers "all" and "every" in conjunction with "a" and "some" on scoping decisions. It was decided to examine "some(pl)" also in conjunction with "all" and "every" (as in the drawing experiments) in the following experiment, Experiment 5.

EXPERIMENT 5.

INTRODUCTION.

The "subject / predicate evaluation" experiments were designed to gain a more accurate picture of the stages associated with disambiguating doubly quantified sentences. Two variables, word order and quantifier type were manipulated. Word order was manipulated by alternating the position of the universal and existential as in the examples below:

Universal 1st	Universal 2nd
"All boys befriend some girls ."	"Some boys befriend all girls.
"Every boy befriends some girls."	"Some boys befriend every girl.

The effect of quantifier type was examined by including two universal and one existential quantifier, "all" and "every" and "some". "Some" was followed by a plural noun phrase,eg "some pupils". This gave sentences such as :

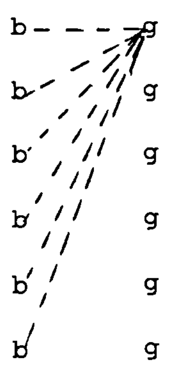
"Some boys befriend all girls."

"Some boys befriend every girl."

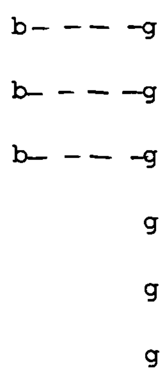
together with their corresponding universal first sentences. The use of "some(pl)" sentences is the main difference between Experiment 4 and Experiment 5. The procedure was identical to Experiment 4. Example diagrams are shown below :

"All boys befriend some girls."

would be followed by these diagrams :



converging



diverging

Predictions for Experiment 5 were the same as those for Experiment 4.

METHOD, EXPERIMENT 5.

SUBJECTS.

Ten undergraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented using a BBC Master series microcomputer. There were two experimental lists, each consisting of 20 sentences. Below are examples of the sentences seen by subjects.

Condition.	Example sentence.
Universal 2nd	
Some(pl)....all	1. Some pupils admire all teachers.
Some(pl)..every	2. Some pupils admire every teacher.
Universal 1st.	
All....some(pl)	3. All teachers are admired by some pupils.
Every..some(pl)	4. Every teacher is admired by some pupils.

The order of presentation of the sentences was randomised by the computer.

A complete list of experimental sentences can be found in Appendix 5(a).

DESIGN.

Experiment 5 investigated two factors:

1. Word order : Universal quantifier 1st vs Universal quantifier 2nd.
2. Type of Universal : All vs Every.

This gave a total of 4 conditions. Two lists, List A and List B were prepared. Both lists consisted of 20 sentences . The order of sentences was as follows :

LIST A			LIST B		
Sentences	1---5	Some(pl)...all	Sentences	1---5	All...some(pl)
	6--10	All...some(pl)		6--10	Some(pl)..All
	11-15	Some(pl).every		11-15	Every.some(pl)
	16-20	Every.some(pl)		16-20	Some(pl).every

Odd numbered subjects saw List A and even numbered subjects saw List B. Subjects saw five sentences in each experimental condition.The order of presentation of sentences was randomised on each list by the microcomputer.

PROCEDURE.

Procedure for Experiment 5 was identical to that for Experiment 4.

MEASURES.

The reading time for sentences in each experimental condition was measured. A measure of the time taken to evaluate each pair of diagrams was taken, and the number of times subjects chose a converging or a diverging diagram in each condition was recorded.

RESULTS AND DISCUSSION.

Appendix 5(b) contains the overall results tables for Experiment 5.The analysis tables for this experiment are in Appendices 5(c)-5(g). As in Experiment 4 missing scores resulted when both diagrams of the same type were rejected for sentences of a particular type. Missing scores were removed from the reading and evaluation time data before the analyses were carried out. Diagram choice analyses refer to data for both converging and diverging diagrams.

DIAGRAM CHOICE.

Prediction : more diverging readings when the universal is first quantifier, more converging readings when the universal is second quantifier.

Prediction : more diverging readings with "every" than with "all".

TABLE 5.4 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS WITH "EVERY" AND "ALL".(Scores out of 5; converging=1, diverging=0).

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
ALL	2.1	2.9	4.4	0.6	3.2	1.7
EVERY	4.4	0.6	2.5	2.5	3.4	2.0
MEANS	3.2	1.7	3.4	1.5		

An analysis of variance on the data contained in Table 5.4 compared sentences containing "all" with sentences containing "every". Results indicated that there was no effect of order, $F1=1.71$, $df=1,9$; $p<.22$; $F2=1.45$, $df=1,8$; $p<.26$. There was an effect of universal on F2 only, ($F2=20.25$, $df=1,8$; $p<.002$; $F1<1$, $df=1,9$); more converging diagrams were chosen following "every" sentences. The analysis also indicated an interaction ,on F1 only, between type of universal and order ($F1=27.56$, $df=1,9$; $p<.0008$; $F2<1$, $df=1,8$;). Subjects were more likely to choose the converging diagram when the universal occurred first in "every" sentences and second in "all" sentences.

Additional observations.

READING TIME.

TABLE 5.5 MEAN READING TIME (MSECS) FOR DOUBLY QUANTIFIED SENTENCE.

Sentence Type / Diagram Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	3019	2960	2989
DIVERGING	3412	3914	3663
MEANS	3215	3437	

Analysis of this data showed no significant effects.

EVALUATION TIME.

TABLE 5.6 MEAN EVALUATION TIME (MSECS) IN EACH CONDITION.

Sentence Type / Diagram Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	4993	4266	4629
DIVERGING	4223	4077	4150
MEANS	4608	4171	

Table 5.6 indicates that overall evaluation time is shorter when the diverging diagram is chosen. An analysis of variance compared evaluation time following "all" sentences in both word order conditions. Results indicated an effect of diagram on F2 only. Subjects were quicker at evaluating the diverging diagram , and this effect was more marked when the universal quantifier occurred first

($F2=16.77$, $df=1,4$; $p<.02$; $F1<1$, $df=1,4$; $p<.73$). There was no effect of order; $F1<1$, $df=1,4$; $p<.86$; $F2<1$, $df=1,4$; $p<.61$).

Analysis of evaluation time following "every" sentences showed no significant results.

The word order prediction was not supported by results from Experiment 5. There were more converging readings in both word order conditions, ie universal first and universal second; this result mirrors what was found in Experiment 4.

The hypothesis that "every" would result in more diverging readings than "all" was also not supported by the data. In fact results indicated that more converging diagrams were chosen (signifying that a converging reading of the sentence had been made) when the universal was first quantifier. This is unusual since one would anticipate that more diverging readings would be made following universal first sentences, especially if the first quantifier was "every", because results from previous experiments have shown "every" to be extremely successful at causing the diverging reading.

Additional observations.

Reading Time data indicated that reading time was shorter when the converging diagram was subsequently chosen. However, analyses of variance on this data showed no effect of order , universal first vs universal second , and no effect of diagram choice, converging vs diverging. It is difficult , therefore, to draw any conclusions from the Reading Time data.

Conversely, Evaluation Time data indicates that evaluation time is shorter when the diverging diagram is subsequently chosen. An analysis of variance showed , on F2 only , that following "all" sentences subjects were quicker at evaluating the diverging diagram, and this effect was enhanced when the universal was first quantifier. No effects of order or diagram were found for "every" sentences, and again it is difficult to draw conclusions from this data.

Results from Experiment 5 are puzzling since they support none of the theories of quantifier scope, ie word order and quantifier characteristics so far outlined. However, missing scores may have rendered results from this experiment unreliable.

Experiments 4 & 5 have looked at active sentences only. The experimenter decided to examine scoping decisions with both active and passive sentences, in both word order conditions, for the following experiments in the "Subject / Predicate Evaluations" set. It was hoped that this strategy would provide a clearer picture of the factors affecting quantifier scope.

EXPERIMENT 6.

INTRODUCTION.

Experiments 4 & 5 investigated the interpretation of doubly quantified active sentences only. The predictions associated with Experiment 4 and Experiment 5 were made with regard to word order and type of universal. However, one factor which Ioup regards as important for determining quantifier scope is the grammatical function of the quantifier. As noted in the Introduction to this thesis, Ioup proposes a hierarchy of grammatical function of the following form :

topic > deep and surface subject > deep subject/surface subject > indirect object > preposition object > direct object.

In Experiments 4 & 5 the universal had appeared as Deep subject & Surface subject in universal first sentences, and Deep object & Surface object in universal second sentences. These positions did not exploit the full range of grammatical functions that could be observed.

In Experiment 6 subjects were presented with a doubly quantified sentence on a microcomputer screen, as in previous experiments. Immediately afterwards they were presented with a single diagram which represented one of the possible interpretations for the sentence they had just seen. Subjects had to judge whether the diagram was appropriate to the sentence.

Experiment 6 investigated word order, grammatical function of the quantifier and type of quantifier. Word order was manipulated by placing the universal as first quantifier in both active and passive sentences, and as second quantifier in both active and passive sentences. This strategy also had the effect of altering the grammatical function of the quantifier which occurs as an interaction between word order and voice. The universal was Deep and Surface subject when it occurred first in active sentences, and Surface subject when it occurred first in passive sentences. The universal was Deep and Surface object when it occurred second in active sentences, and Deep subject when it occurred second in passive sentences. The effect of type of quantifier was investigated by including two types of universal quantifier, namely "all" and "every", and two types of existential quantifier, "a" and "some". These manipulations provided sentences like the following :

SET 1

Condition: ACTIVE,UNIVERSAL FIRST.

All boys befriend a girl.

Every boy befriends a girl.

All boys befriend some girl.

Every boy befriends some girl.

SET 2

Condition: ACTIVE,UNIVERSAL SECOND.

A boy befriends all girls.

A boy befriends every girl.

Some boy befriends all girls.

Some boy befriends every girl.

SET 3

Condition: PASSIVE,UNIVERSAL FIRST.

All boys are befriended by a girl.

Every boy is befriended by a girl.

All boys are befriended by some girl.

Every boy is befriended by some girl.

SET 4

Condition: PASSIVE,UNIVERSAL SECOND.

A boy is befriended by all girls.

A boy is befriended by every girl.

Some boy is befriended by all girls.

Some boy is befriended by every girl.

The predictions arising from these variables are as follows. The word order hypothesis of Johnson-Laird holds that when the universal is first quantifier more diverging readings will result, and when the universal is second quantifier more converging readings will result.

Ioup's predictions relating to grammatical function are that when the universal takes Deep and Surface subject position the diverging reading only should result. In Surface subject position the diverging interpretation should be preferred, and this should also be the case for Deep subject position. When the universal is Deep and Surface object the converging reading should be preferred. The word order and grammatical function predictions interlock and predict the same outcome except in the case of passive sentences where the universal is second quantifier. Here Johnson-Laird would predict the converging reading and Ioup would predict the diverging reading.
Ioup also predicts differences according to the type of universal. The prediction is that "every" will result in more diverging readings than "all" regardless of its position in a sentence; this prediction has been supported in earlier experiments.

Additional observations.

As an additional observation the experiment investigated whether more converging readings were made with "a" or "some".

Reading times for the doubly quantified sentence were also examined on the assumption that longer reading times reflect greater complexity for the comprehension system.

Evaluation times for the diagram were also examined on the assumption that shorter evaluation times would reflect the facilitation effect of experimental conditions. That is, subjects would evaluate a diagram consistent with their model of the doubly quantified sentence more quickly than one which was inconsistent with the model.

METHOD, EXPERIMENT 6.

SUBJECTS.

Sixty four undergraduate and postgraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented singly using a BBC Master Series microcomputer. There were eight experimental lists, each consisting of 64 sentences. Example sentences appear on the previous page.
In Set 1 the universal was deep and surface subject, in Set 2 the universal was deep and surface object, in Set 3 the universal was surface subject and in Set 4 the universal was deep subject.
A complete list of experimental sentences can be found in Appendix 6(a)

DESIGN.

Experiment 6 investigated five factors:

1. Word order : Universal quantifier 1st vs Universal quantifier 2nd.
2. Type of Universal : All vs Every
3. Type of existential : A vs Some
4. Voice : Active vs Passive
5. Type of Diagram : converging vs diverging

This gave a total of 32 conditions. Eight experimental lists were prepared. The lists consisted of 64 sentences, two in each of the experimental conditions. Lists were organised so that within each quantifier pair (ie a/all, some/all, a/every, and some/every) the order of conditions rotated . This rotation ensured that all the experimental sentences appeared in each experimental condition.

Subjects also saw a list of 32 filler sentences of the same type as experimental sentences, eg:

"A salesman persuades all buyers".

Sentences on this list were followed by a diagram which was obviously inappropriate to the sentence. The filler list was included for two reasons; firstly to avoid a response bias , because it was possible to accept every diagram which followed the experimental sentences, and secondly to avoid familiarity effects, since of the diagrams following the experimental sentences 32 were what the experimenter termed "parallel" diagrams, 16 were "converging right" diagrams and 16 were "converging left" diagrams. An illustration of the experimental diagrams is included in Appendix 6(b).The filler sentence data was not used in the analysis of this experiment. Diagrams following the filler sentences brought the number of diagrams to 32 of each type. The order of presentation of the sentences was randomised by the computer. Subjects saw a practice list of 15 sentences.

Subjects were assigned to lists by means of a matrix as follows:

LIST	SUBJECTS
1	1, 9,17,25,33,41,49,57.
2	2,10,18,26,34,42,50,58.
3	3,11,19,27,35,43,51,59.
4	4,12,20,28,36,44,52,60.
5	5,13,21,29,37,45,53,61.
6	6,14,22,30,38,46,54,62.
7	7,15,23,31,39,47,55,63.
8	8,16,24,32,40,48,56,64.

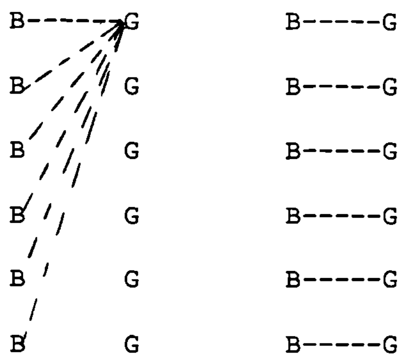
PROCEDURE.

Subjects were tested singly in a self-paced reading and evaluation task. They were given a typed sheet of instructions which read as follows:

"You will see a series of sentences which will appear one at a time on the computer screen. I would like you to read the sentence and press the space bar as soon as you have done so. The sentence will disappear and will be followed by a diagram.Your task is to judge whether the diagram accurately represents the sentence you have just read. For example, if you get a sentence like this:

"A boy befriends all girls".

the diagram which follows will be like those below:



Each sentence will be followed by only one diagram. If you think the diagram "fits" the sentence you have just read press the "YES" key. If you think the diagram is not appropriate to the sentence press the "NO" key.

Work your way through the experiment as quickly as you can but make sure you understand the sentences you read. There is a practice session first. Do you have any questions?".

The sentences were presented one at a time in normal case. Subjects were asked to press the space bar as soon as they had read the sentence. This key press removed the sentence from the screen and one of the two diagrams,representing either the converging or the diverging interpretations for each sentence appeared on the screen. The diagrams always appeared at the centre of the screen.

Subjects then had to press a key marked "YES" if they thought the diagram was an accurate representation of the sentence they had just read, or a key marked "NO" if they thought the diagram was not an accurate representation of the sentence. The key marked "NO" was at the letter "E" position on the keyboard (ie at the left-hand side of the keyboard), and the key marked "YES" was at the letter "I" position on the keyboard, (ie at the right-hand side of the keyboard). This key press removed the diagram from the screen and the next experimental sentence appeared.

Subjects were advised to keep their left hand positioned over the "NO" key and their right hand positioned over the "YES" key. They were also advised to use their thumbs to press the space bar. This method facilitated speed of response. When the final sentence had been read and the diagram evaluated the final key press caused the message "That's all thankyou. You can go now." to appear.

The experimenter remained with the subject for the duration of the practice list and was available to answer any questions. After the practice list was completed the subject was left alone to finish the experiment. Subjects normally took about fifteen minutes to complete the experiment .

MEASURES.

The reading times for sentences in each experimental condition was measured. A measure of the time taken to evaluate each diagram was taken, and the number of times subjects chose a converging or a diverging diagram in each condition was recorded.

RESULTS AND DISCUSSION.

The overall results for Experiment 6 are included in Appendix 6(c). Reading time and evaluation time analyses refer to data from "YES" responses to the converging diagram only. A score of one was assigned each time subjects pressed the "YES" key and accepted the diagram but this strategy resulted in missing scores for reading and evaluation time in those cases where subjects had rejected a particular diagram type on both occasions when it was presented with a certain sentence type. This is because reading and evaluation time are contingent upon subsequent diagram choice.The data revealed missing scores for the diverging diagram conditions and so this data was omitted from the reading and evaluation time analyses. Of the remaining data, lines where zero scores occurred were also removed. Analyses for diagram choice data refer to data for "YES" responses to both diagram types. The complete analysis tables for this experiment are in Appendices 6(d)-6(i). Discussion of tables 6.4 to 6.7 is based on an analysis of variance shown in Appendices 6(d) and 6(e).

Prediction : more diverging readings when the universal is first, more converging readings when the universal is second quantifier.

TABLE 6.4 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS ACCORDING TO WORD ORDER.(Scores out of 2)

Sentence Type		UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type				
CONVERGING		1.55	1.66	1.60
DIVERGING		1.20	0.97	1.08
	MEANS	1.37	1.31	

An analysis of variance on the data indicated an effect of diagram. Subjects were more likely to accept the converging diagram; $F1=55.29$, $df=1,63$; $p<.000001$; $F2=329.14$, $df=1,60$, $p<.000001$. There was an effect of order on F2 only, $F2=67.84$, $df=1,60$; $p<.000001$; $F1=3.33$, $df=1,63$; $p<.07$. There was also an interaction between order and diagram; subjects were more likely to accept the converging diagram following universal second sentences, $F1=36.18, df=1,63$; $p <.00001$; $F2=418.55$, $df=1,60$; $p<.000001$.

Prediction : Diverging reading only when the universal is deep and surface subject, diverging preferred when the universal is deep subject or surface subject, converging preferred when the universal is deep and surface object.

TABLE 6.5 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS ACCORDING TO GRAMMATICAL FUNCTION OF THE UNIVERSAL. (Scores out of 2)

Sentence Type	ACTIVE		PASSIVE		MEANS
Order	U 1st	U 2nd	U 1st	U 2nd	
Grammatical Function	DS & SS	DO & SO	SS	DS	
CONVERGING	1.52	1.61	1.57	1.71	1.60
DIVERGING	1.14	1.03	1.26	0.96	1.10
MEANS	1.33	1.41	1.32	1.33	

Analysis of the data shown in Table 6.5 showed that there was an effect of voice on F1 data only; subjects were more likely to accept the diagram following passive sentences than actives, $F1=3.93$, $df=1,63$; $p <.04$; $F2=2.96$, $df=1,60$; $p <.09$. There was no interaction between diagram and voice, F1=1, df=1,63; F2=1, df=1,60, nor between voice and order, F1=2.38, df=1,63; F2<1, df=1,60. However, there was a three-way interaction between order, voice and diagram, F1=4.77, df=1,63; p<.03; F2=12.32, df=1,60; p<.001.

Prediction : More diverging readings with "every" than with "all".

TABLE 6.6 MEAN NUMBER OF DIVERGING READINGS WITH EVERY AND ALL. (Scores out of 2).

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
ALL	1.21	0.98	1.09
EVERY	1.57	1.01	1.29
MEANS	1.39	0.99	

An analysis indicated an interaction between universal and diagram, F1=8.61, df=1,63; p <.005; F2=33.24, df=1, 60; p<.00001. Though there was no difference in the number of diverging readings given to each universal quantifier, the converging reading was more likely to be accepted following "all" sentences.

Additional observations.

TABLE 6.7 MEAN NUMBER OF CONVERGING DIAGRAMS WITH "A" AND "SOME". (Scores out of 2).

Sentence Type	EXISTENTIAL 1ST		EXISTENTIAL 2ND		MEANS
	A	SOME	A	SOME	
ALL	1.89	1.63	1.80	1.49	1.71
EVERY	1.73	1.38	1.60	1.28	1.54
MEANS	1.81	1.50	1.70	1.38	

There was an effect of existential "a" vs "some". Subjects were more likely to accept the diagram following "a" sentences than "some" sentences, F=53.19, df=1,63, p<.00001; F2=3.97, df=1, p<.05. There was an interaction between existential and diagram. Subjects were more likely to accept the converging diagram following "a" sentences, F1=173.63, df=1,63; p <.00001, F2=13.88, df=1,60; p <.0007. There was a three way interaction between order , voice and diagram, F1=16.90, df=1,63; p<.0003; F2=12.32, df=1, p<.001.

READING TIMES.

There are no specific predictions for Reading times though the experimenter assumes that longer reading times reflect greater complexity for the comprehension system.

TABLE 6.8 MEAN READING TIME (MSECS) FOR SENTENCES ACCORDING TO WORD ORDER

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type			
CONVERGING	2151	2207	2179

An effect of order was found on F2 only; universal first sentences had faster reading times. (F2=6.38, df=1,52; p<.014; F1<1, df=1,28; p <.6).

TABLE 6.9 MEAN READING TIMES ACCORDING TO GRAMMATICAL FUNCTION OF THE UNIVERSAL.

Sentence Type	ACTIVE		PASSIVE		MEAN
Order	U 1st	U 2nd	U 1st	U 2nd	
Grammatical Function	DS & SS	DO & SO	SS	DS	
Diagram Type					
CONVERGING	1974	2056	2328	2358	2179

Analysis of the data did not reveal an effect of grammatical function, ie an interaction between order and voice . There was an effect of voice; active sentences were read faster than passives, F1=31.58, df=1,28; p <.00004; F2=30.52, df=1,52; p <.00002).

TABLE 6.10 MEAN READING TIME (MSECS) ACCORDING TO EXISTENTIAL.

Sentence Type	EXISTENTIAL 1ST		EXISTENTIAL 2ND		MEANS
	A	SOME	A	SOME	
ALL	2203	2359	1940	2295	2199
EVERY	2191	2074	2122	2248	2159
MEANS	2197	2216	2031	2271	

Analysis of this data indicated an effect of existential on F2 only; F2=6.60, df=1,52; p< .01, though the effect was close to significance on F1, F1=3.53, df=1,28; p<.067.

EVALUATION TIMES.

Discussion of tables 6.11 to 6.13 is based on a single analysis of variance for subject data which appears in Appendix 6(h) and a single analysis of variance for sentence data which appears in Appendix 6(i).

Prediction : shorter evaluation times following universal second sentences.

TABLE 6.11 MEAN EVALUATION TIME (MSECS) ACCORDING TO WORD ORDER.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEAN
Diagram Type			
CONVERGING	1943	1709	1826

An analysis of the data revealed an effect of order. Evaluation was faster following universal second sentences; F1=19.36, df=1,29; p<.0003; F2=19.51, df=1,52; p<.0002).

Prediction : faster evaluation times when the universal is deep and surface object.

TABLE 6.12 MEAN EVALUATION TIMES ACCORDING TO GRAMMATICAL FUNCTION OF THE UNIVERSAL.

Sentence Type	ACTIVE		PASSIVE		MEAN
Order	U 1st	U 2nd	U 1st	U 2nd	
Grammatical Function	DS & SS	DO & SO	SS	DS	
Diagram Type					
CONVERGING	1902	1657	1984	1761	1826

An analysis of variance showed no effect of grammatical function, ie no interaction between order and voice.

Prediction : faster evaluation times following "a" sentences than "some" sentences.

TABLE 6.13 MEAN EVALUATION TIME (MSECS) ACCORDING TO EXISTENTIAL.

Sentence Type	EXISTENTIAL 1ST		EXISTENTIAL 2ND		MEANS
	A	SOME	A	SOME	
ALL	1529	1754	1779	2000	1765
EVERY	1766	1790	1971	2024	1888
MEANS	1647	1772	1875	2012	

An analysis indicated an effect of existential. Evaluation time was faster following "a" sentences, F1=4.39, df=1,29; p <.04; F2=4.03, df=1,52; p <.05).

Scores for the converging diagram indicated support for the word order hypothesis, since more converging readings resulted following universal second sentences. Evaluation time data also provided support for the word order hypothesis, since evaluation time was faster for the converging diagram following universal second sentences.
Reading time data indicated that universal first sentences were read more quickly though this was not a strong effect. Subjects have not seen the converging diagram at this stage.

Although grammatical function is not a factor in the analysis of this experiment, the grammatical function of the universal is revealed by an interaction between word order and voice. Grammatical function is detailed in the Method section of the experiment where the grammatical function of the universal is clarified for each condition. With regard to the grammatical function hypothesis, there was no effect of grammatical function with data for diagram acceptance, reading time data or evaluation time data. Scores for diagram acceptance and evaluation times are in the predicted direction but this result is also compatible with the word order hypothesis.

Data from the diagram acceptance scores showed that "a" sentences had more converging readings than "some" sentences. Evaluation time data indicated that evaluation time was faster for the diagram following "a" sentences. These results indicate that "a" is superior to "some" in inducing the converging reading.

Experiment 6 looked at the universal quantifiers "all" and "every" with "a" and "some". In order to complete this set of experiments it was decided to examine "all" and "every" with "some(pl)" in the following experiment, Experiment 7.

EXPERIMENT 7.

INTRODUCTION.

Experiment 7 was a replication of Experiment 6, using the same manipulations of word order, grammatical function and type of universal. However, Experiment 7 included only one existential quantifier, "some" followed by a plural noun phrase, (eg "some boys"), afterwards referred to as "some(pl)". These manipulations provided sentences like the following :

SET 1	SET 2
Condition:ACTIVE,UNIVERSAL FIRST.	Condition:ACTIVE,UNIVERSAL SECOND
All boys befriend some girls.	Some boys befriend all girls.
Every boy befriends some girls.	Some boys befriend every girl.
SET 3	SET 4
Condition:PASSIVE,UNIVERSAL FIRST.	Condition:PASSIVE,UNIVERSAL SECOND
All boys are befriended by some girls.	Some boys are befriended by all girls.
Every boy is befriended by some girls.	Some boys are befriended by every girl.

METHOD, EXPERIMENT 7.

SUBJECTS.

Thirty two undergraduate and postgraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Examples of the sentences seen by subjects are shown on the previous page.

In Set 1 the universal was deep and surface subject, in Set 2 the universal was deep and surface object, in Set 3 the universal was surface subject and in Set 4 the universal was deep subject.

A complete list of experimental sentences can be found in Appendix 7(a)

DESIGN.

Experiment 7 investigated four factors:

1. Word order : Universal quantifier 1st vs Universal quantifier 2nd.
2. Type of Universal : All vs Every.
3. Voice : Active vs Passive.
4. Type of Diagram : converging vs diverging.

This gave a total of 16 conditions. Eight experimental lists were prepared. The lists consisted of 32 sentences, two in each of the experimental conditions. Lists were organised so that within each quantifer pair (ie all / some(pl) & every / some(pl)) the order of conditions rotated . This rotation ensured that all the experimental sentences appeared in each experimental condition.

Subjects also saw a list of 16 filler sentences which were identical in type to experimental sentences, eg:.

"Some salesmen persuade all buyers".

Sentences on this list were followed by a diagram which was obviously inappropriate to the sentence. The filler list was included for two reasons; firstly to avoid a response bias , because it was possible to accept every diagram which followed the experimental sentences, and secondly to avoid familiarity effects, since of the diagrams following the experimental sentences 16 were what the experimenter termed "parallel" diagrams, 8 were "converging right" diagrams and 8 were "converging left" diagrams. An illustration of the experimental diagrams is included in Appendix 7(b).The filler sentence data was not used in the analysis of this experiment. Diagrams following the filler sentences brought the number of diagrams to 16 of each type. The order of presentation of the sentences was randomised by the computer. Subjects saw a practice list of 15 sentences.

Subjects were assigned to lists by means of a matrix as follows:

LIST	SUBJECTS
1	1, 9,17,25
2	2,10,18,26
3	3,11,19,27
4	4,12,20,28
5	5,13,21,29
6	6,14,22,30
7	7,15,23,31
8	8,16,24,32

PROCEDURE.

Procedure was identical to that for Experiment 6.

MEASURES

The reading times for sentences in each experimental condition was measured. A measure of the time taken to evaluate each diagram was taken, and the number of times subjects chose a converging or a diverging diagram in each condition was recorded.

RESULTS AND DISCUSSION.

The overall results for Experiment 7 are included in Appendix 7(c). Complete analysis tables for this experiment are in Appendices 7(d)-7(i). For the same reason as Experiment 6 analyses for reading and evaluation time data refer to data for "YES" responses to the converging diagram only. Diagram choice analyses refer to data for "YES" responses to both converging and diverging diagrams. A score of one was assigned each time subjects pressed the "YES" key and accepted the diagram; mean scores included in the tables are out of two.

DIAGRAM CHOICE.

Prediction : more diverging diagrams when the universal is first quantifier, more converging readings when the universal is second quantifier.

TABLE 7.4 MEAN NUMBER OF CONVERGING AND DIVERGING DIAGRAMS ACCORDING TO WORD ORDER (Scores out of 2).

Sentence Type.	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
CONVERGING	1.59	1.85	1.72
DIVERGING	1.09	0.34	0.71
MEANS	1.34	1.09	

An analysis of variance was carried out on the data from diagram scores. The analysis indicated an effect of order; people were more likely to accept the diagram following universal first sentences, ($F1=20.45$, $df=1,31$; $p<.0002$; $F2=38.96$, $df=1$; $p<.00002$). There was also an effect of diagram; people were more likely to accept the converging diagram, $F1=96.49$, $df=1,31$; $p<.000001$; $F2=617.40$, $df=1$; $p<.000001$. There was an interaction between order and diagram; people were more likely to accept the converging diagram following universal second sentences; there was no difference following universal first sentences. ($F1=41.15$, $df=1,31$; $p<.00001$; $F2=192.2$, $df=1$; $p<.000001$). There was a three way interaction between order, universal and diagram, $F1=4.10$, $df=1,31$, $p<.05$; $F2=4.05$, $df=1,30$; $p<.05$.

Prediction : Diverging reading only when universal is Deep and Surface subject, diverging reading preferred when universal is Deep or Surface subject, converging reading preferred when universal is Deep and Surface object.

TABLE 7.5 MEAN NUMBER OF CONVERGING AND DIVERGING DIAGRAMS ACCORDING TO GRAMMATICAL FUNCTION OF THE UNIVERSAL. (Scores out of 2.)

Sentence Type	ACTIVE		PASSIVE		MEANS
Order	U 1st	U 2nd	U 1st	U 2nd	
Grammatical function	DS & SS	DO & SO	SS	DS	
CONVERGING	1.48	1.89	1.70	1.81	1.72
DIVERGING	1.15	0.28	1.04	0.40	0.72
MEANS	1.31	1.08	1.37	1.10	

An analysis of variance on the data showed no effect of grammatical function, ie no interaction between order and voice.

Prediction : more diverging readings with "every" than with "all".

TABLE 7.6 MEAN NUMBER OF DIVERGING DIAGRAMS WITH "EVERY" AND "ALL".

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
ALL	1.17	0.28	0.72
EVERY	1.03	0.40	0.71
MEANS	1.10	0.34	

An analysis of variance on this data showed no significant results.

Additional observations.

READING TIMES.

TABLE 7.7 MEAN READING TIMES (MSECS) FOR SENTENCES ACCORDING TO WORD ORDER.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEAN
Diagram Type			
CONVERGING	2162	1998	2080

An analysis showed no effect of order.

TABLE 7.8 MEAN READING TIME (MSECS) ACCORDING TO GRAMMATICAL FUNCTION OF THE UNIVERSAL.

Sentence Type	ACTIVE		PASSIVE		MEAN
Order	U 1st	U 2nd	U 1st	U 2nd	
Grammatical function	DS & SS	DO & SO	SS	DS	
Diagram Type					
CONVERGING	2149	1932	2176	2065	2080

An analysis of the data revealed no effect of grammatical function ie no interaction between order and voice.

EVALUATION TIMES.

Prediction : faster evaluation times for universal second sentences.

TABLE 7.9 MEAN EVALUATION TIMES (MSECS) ACCORDING TO WORD ORDER.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEAN
Diagram type			
CONVERGING	2300	2144	2222

An analysis showed no effect of order.

Prediction : faster evaluation times when the universal is Deep and Surface object.

TABLE 7.10 MEAN EVALUATION TIME (MSECS) ACCORDING TO GRAMMATICAL FUNCTION OF THE UNIVERSAL.

Sentence Type	ACTIVE		PASSIVE		MEAN
Order	U 1st	U 2nd	U 1st	U 2nd	
Grammatical function	DS & SS	DO & SO	SS	DS	
Diagram Type					
CONVERGING	2327	2141	2273	2147	2222

An analysis showed no effect of grammatical function, ie no interaction between order and voice.

As in Experiment 6 grammatical function was not a factor in the analysis of this experiment, but is revealed as an interaction between order and voice. Results from Experiment 7 showed no significant effect of grammatical function, though the data were in the predicted direction. However, the universal appears as deep and surface object in universal second sentences, for which the word order hypothesis proposes identical results.

Support for the word order hypothesis was, however, limited with no effect of word order in Reading Time or Evaluation Time data. There was a suggestion from the data regarding the number of converging diagrams accepted that universal second sentences induced more converging readings.

DISCUSSION OF EXPERIMENTS 4, 5, 6 & 7.

Johnson-Laird's word order hypothesis received limited support from this set of experiments. Experiments 4 & 5 showed more converging readings in both word order conditions; Johnson-Laird predicts the converging reading for universal second sentences only. Experiments 6 & 7 showed an effect of order consistent with Johnson-Laird's theory, with the converging reading more popular following universal second sentences (though the converging diagram was more popular overall in both experiments). In Experiment 6 evaluation time was faster following universal second sentences, a result which is predicted by the word order hypothesis, and in Experiment 4 evaluation time was faster following "a" sentences when the converging diagram was subsequently chosen, which is also consistent with the word order theory. It is worth noting that reading time and evaluation time analyses for Experiments 6 & 7 were carried out on data for the converging diagram only since diverging diagram data did not provide a sufficient number of scores. This indicates that the converging diagram was the more popular choice as a representation of the experimental sentences.

In the first set of experiments (1-3) one robust result was that "every" consistently evoked more diverging readings than "all" regardless of its position in a sentence. This was not the case with Experiments 4 & 5. In Experiments 4 & 5 "every" caused more diverging readings than "all" only in universal second sentences; with the universal quantifiers in this position people were more likely to make the converging reading in any case. Experiment 7 showed no significant difference in the number of diverging readings given to "every" and "all". In Experiment 6 there was no difference in the number of diverging readings given to each universal, but the converging reading was more likely to be accepted following "all" sentences. The experimenter was aware of an effect of task here, since in the Drawing Experiments (1-3) "every" proved more powerful than "all".

Differences between the existential quantifiers "a" and "some" were examined in Experiments 4 & 6. (Experiments 5 & 7 used only "some(pl)" and so a comparison could not be made.) Experiment 4 indicated that results were in the predicted direction with "a" inducing more converging readings than "some" but the data was not significant. However, Experiment 6 showed support for the prediction . More converging diagrams were chosen following "a" sentences and evaluation time for the converging diagram was faster following "a" sentences, especially active versions of these sentences. An effect of task was noticeable here since in the drawing experiments there were some unexpected exceptions to the tendency for "a" to take wide scope.

Turning now to grammatical function of the universal, a factor examined in Experiments 6 & 7; no significant effects were found either in the number of diagrams chosen, reading time or evaluation time data. The effect of grammatical function should be revealed as an interaction between order and voice, but no interaction of this nature was indicated.Ioup predicted that the converging reading would be preferred when the universal took deep and surface object position, and although results from Experiments 6 & 7 were in this direction they were not significant. In this case Ioup's prediction is also consistent with the word order theory.

One problem with the data from Experiments 4 & 5 is that of missing scores. The design of these experiments meant that the two diagrams representing the converging and diverging interpretation were presented simultaneously. Obviously people could not accept both diagrams and had to reject one. Occasionally this led to all examples of a diagram type being rejected for a particular sentence type and a zero or missing score resulted. Also, because the two diagrams were presented together evaluation time data reflected the time subjects took to evaluate both diagrams . It is not possible to claim, therefore, that evaluation time concerns the diagram which people chose. It is possible that the data from Experiments 4 & 5 may not be reliable because of missing scores.

For Experiments 6 & 7 the problem of missing scores in the reading and evaluation time data was dealt with by concentrating only on those cases where people chose a converging diagram, since there were many missing scores for diverging diagrams. The data was abbreviated further by removing zero scores from the converging diagram data. However, there were fewer missing scores in Experiments 6 & 7 than in Experiments 4 & 5 because subjects only had to make a decision about one diagram at a time and not two. Thus the data from 6 & 7 should be more robust than that from 4 & 5.

For the following set of experiments, Dative Constructions, the experimenter altered the type of doubly quantified sentences subjects saw. This was to examine Ioup's hierarchy of quantifier scope and to see if results so far would hold with different sentence constructions. It was also felt that Dative Constructions were closer. to natural language sentences.

CHAPTER 4.

DATIVE CONSTRUCTIONS, EVALUATION TASK.

EXPERIMENT 8.

INTRODUCTION.

The experiments so far described have all used similar sentences, referred to as subject / predicate constructions. These were followed either by a drawing task or a diagram evaluation task. For Experiment 8 this type of sentence construction was discarded in favour of dative constructions. One example of these is :

"Susan gave some friends a recipe."

Dative constructions in Experiment 8 contained a variety of lexical material.

There were two reasons for the change to dative constructions. Firstly the experimenter wanted to examine Ioup's hierarchy of quantifiers more fully. Previous experiments had examined the quantifiers "a", "some" and "some(pl)" in sentences containing "all" and "every", but these sentences did not contain all the quantifiers in Ioup's hierarchy. The quantifiers Ioup describes are "each", "every", "all", "most", "many" "several" and "some" followed by a plural noun. The type of sentence illustrated above is appropriate for testing the quantifiers in Ioup's hierarchy. Secondly the experimenter felt that dative constructions yielded sentences which were more likely to occur in natural language than those sentences which were used in previous experiments.

Experiment 8 investigated the effect of word order and the characteristics of individual quantifiers on quantifier scope. Word order was manipulated by placing the universal quantifier as either first or second quantifier. For the purpose of this experiment the term "universal" covers the multiple quantifiers "some", "several", "many", "most", "all", "every" and "each" used in the experiment. The experimenter decided to treat "some" as if it were a universal quantifier becuase results from earlier experiments indicated a difference between "a" and "some" ; "a" was more likely overall to induce the converging reading than "some". The design of the experiment ensured that it was possible to distinguish between the effects of the universal quantifiers, so that any difference between "some" and the other multiple quantifiers would be apparent. The effect of the individual characteristics of quantifiers was investigated by including the seven universal quantifiers listed above. This gave sentences like the following :

Condition : Universal first.

Susan gave some friends a recipe.

Susan gave several friends a recipe

Susan gave many friends a recipe.

Susan gave most friends a recipe.

Susan gave all friends a recipe.

Susan gave every friend a recipe.

Susan gave each friend a recipe.

Condition : Universal second.

Susan gave a recipe to some friends.

Susan gave a recipe to several friends.

Susan gave a recipe to many friends.

Susan gave a recipe to most friends.

Susan gave a recipe to all friends.

Susan gave a recipe to every friend.

Susan gave a recipe to each friend.

Inspection of these sentences shows that some of them are more "acceptable" than others. However, the quantifier pairs occurred within different sentence frames, (i.e. with different nouns) so that the problem of acceptability could be diminished.

The predictions arising from these factors are as follows. More diverging readings will result when the universal is first quantifier, and more converging readings will result when the universal is second quantifier. The characteristics of different quantifiers are such that according to Ioup "some" will be more likely to result in the converging reading ; this tendency will decline as the hierarchy descends so that with "every" Ioup predicts that the diverging reading will result. As the quantifiers define larger sets the preferred reading for the sentence should alter from the converging reading for those quantifiers that identify relatively small sets to the diverging reading for those that identify larger sets. (But see Newstead, 1988 for a fuller discussion).

Additional observations.

Reading times for the doubly quantified sentence were examined on the assumption that longer reading times reflect greater complexity for the comprehension system.

Evaluation times for the two diagrams were also examined on the assumption that shorter evaluation times would reflect the facilitation effect of experimental conditions. That is, subjects would evaluate a diagram consistent with their model of the doubly quantified sentence more quickly than one which was inconsistent with the model.

METHOD, EXPERIMENT 8.

SUBJECTS.

112 undergraduate and postgraduate students from the University of Durham took part in the experiment. None had had tuition in Logic.

MATERIALS.

Sentences were presented singly using a BBC Master series microcomputer. There were fifty six experimental lists, each consisting of 70 sentences. Below are examples of sentences seen by subjects.

SET 1, UNIVERSAL FIRST.

Susan gave some friends a recipe.

Malcolm passed several students a glass.

Maisie left many people a gift.

Eleanor threw most players a ball.

Katie made all supporters a mascot.

Antony showed every designer a sketch.

Melanie sent each traveller a postcard.

SET 2, UNIVERSAL SECOND.

Susan gave a recipe to some friends.

Malcolm passed a glass to several students.

Maisie left a gift for many people.

Eleanor threw a ball to most players.

Katie made a mascot for all supporters.

Antony showed a sketch to every designer.

Melanie sent a postcard to each traveller.

The universal was indirect object in all sentences.

A complete list of experimental sentences appears in Appendix 8(a).

DESIGN.

Experiment 8 investigated three factors:

1. Word order : Universal quantifier 1st vs Universal quantifier 2nd.
2. Quantifier : A with some, several, many, most, all, every and each.
3. Type of Diagram : converging vs diverging.

This gave a total of 28 conditions; the seven quantifier conditions appeared either with the universal first or second, giving 14 conditions, and sentences were followed either by a converging or a diverging diagram, giving 28 conditions.Fifty six experimental lists were prepared. The lists consisted of 70 sentences, five in each of the experimental conditions. Lists 1 to 28 contained sentences in which the universal quantifier occurred first, (ie "SET 1" sentences). Lists 29 to 56 contained sentences in which the universal quantifier occurred second,(ie "SET 2" sentences).

On lists 1-14, the first five examples of each quantifier were followed by a diagram illustrating the converging interpretation for the sentence, and the second five examples of each quantifier were followed by a diagram illustrating the diverging interpretation for the sentence. This pattern was also used for lists 29-42. On lists 15-29, and on lists 43-56, the first five examples of each quantifier were followed by a diagram illustrating the diverging interpretation for the sentence, and the second five examples of each quantifier were followed by a diagram illustrating the converging interpretation for the sentence.

Lists were organised so that all the quantifer pairs (ie a / some, a /

several, a / many, a / most, a / all, a / every,and a / each) appeared in each experimental sentence frame. This organisation ensured that all the experimental sentences appeared in each experimental condition.

Subjects also saw a list of 50 filler sentences. Sentences on this list were followed by a diagram which was obviously inappropriate to the sentence. An example sentence is shown below:

"Fiona made a drink for some visitors."

The filler list was included in order to prevent a response bias since it was possible to accept every diagram which followed the experimental sentences. The filler sentence data was not used in the analysis of this experiment.Subjects also saw a practice list of 21 sentences. Halfway through the experiment there was a short rest period of two minutes duration.The order of presentation of the sentences was randomised by the computer.

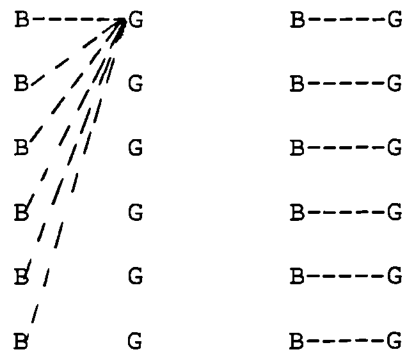
PROCEDURE.

Subjects were tested singly in a self-paced reading and evaluation task. They were given a typed sheet of instructions which read as follows:

"You will see a series of sentences which will appear one at a time on the computer screen. I would like you to read the sentence and press the space bar as soon as you have done so. The sentence will disappear and will be followed by a diagram.Your task is to judge whether the diagram accurately represents the sentence you have just read. For example, if you get a sentence like this:

"Shirley gave a book to some girls".

the diagram which follows will be like those below:



Each sentence will be followed by only one diagram. If you think the diagram "fits" the sentence you have just read press the "YES" key. If you think the diagram is not appropriate to the sentence press the "NO" key.

Work your way through the experiment as quickly as you can but make sure you understand the sentences you read. Halfway through the experiment there is a short rest period. There is a practice session first. Do you have any questions?".

The sentences were presented one at a time in normal case. Subjects were asked to press the space bar as soon as they had read the sentence. This key press removed the sentence from the screen and one of the two diagrams,representing either the converging or the diverging interpretations for each sentence appeared on the screen. The diagrams always appeared at the centre of the screen.
Subjects then had to press a key marked "YES" if they thought the diagram was an accurate representation of the sentence they had just seen, or a key marked "NO" if they thought the diagram was not an accurate representation of the sentence. The key marked "NO" was at the letter "E" position on the keyboard (ie at the left-hand side of the keyboard), and the key marked "YES" was at the letter "I" position on the keyboard, (ie at the right-hand side of the keyboard). This key press removed the diagram from the screen and the next experimental sentence appeared. Midway through the experiment the message "Short pause now, please wait." appeared on the screen. After a two minute break the computer signalled the end of the rest period by sounding a tone and the message "Press space bar for next sentence." appeared on the screen.

Subjects were advised to keep their left hand positioned over the "NO" key and their right hand positioned over the "YES" key. They were also advised to use their thumbs to press the space bar. This method facilitated speed of response. When the final sentence had been read and the diagram evaluated the final key press caused the message "That's all thankyou. You can go now." to appear.
The experimenter remained with the subject for the duration of the practice list and was available to answer any questions. After the

practice list was completed the subject was left alone to finish the experiment. Subjects normally took about twenty minutes to complete the experiment .

MEASURES.

The reading times for sentences in each experimental condition was measured. A measure of the time taken to evaluate each diagram was taken, and the number of times subjects chose a converging or a diverging diagram in each condition was recorded.

RESULTS AND DISCUSSION.

The overall results for Experiment 8 are included in Appendix 8(b). The analysis tables for this experiment are in Appendices 8c-8e. Reading time and evaluation time data refer to data from "YES" responses to diverging diagrams only. This strategy was used to overcome the problem of missing scores which were especially prevalent with converging diagram data. Diagram choice analyses refer to data from "YES" responses to converging and diverging diagrams. A score of one was assigned each time subjects pressed the "YES" key and accepted the diagram; mean scores included in the tables are out of five.

Prediction : more diverging readings when the universal is first, more converging readings when the universal is second quantifier.

TABLE 8.4 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH WORD ORDER CONDITION.(scores out of 5)

Sentence Type		UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type				
CONVERGING		3.92	2.98	3.45
DIVERGING		4.10	4.19	4.14
	MEANS	4.01	3.58	

An analysis of variance on this data revealed an effect of diagram; $F1=33.30$, $df=1,110$, $p <.00001$; $F2=8.00$, $df=1,69$, $p <.006$; the diverging diagram was more likely to be accepted. The analysis also indicated an interaction between diagram and order; $F1=18.05$, $df=1,110$, $p <.0002$; $F2=210.31$, $df=1,69$; $p <.000001$. Subjects were more likely to accept the converging diagram following universal first sentences.

Prediction : more diverging readings according to Ioup's hierarchy.

TABLE 8.5 MEAN NUMBER OF DIVERGING READINGS ACCORDING TO QUANTIFIER. (Scores out of 5.)

Sentence Type Condition	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
some	3.89	3.21	3.55
several	4.02	3.87	3.94
many	4.14	3.73	3.93
most	4.21	4.50	4.35
all	4.16	4.11	4.13
every	4.46	4.62	4.54
each	4.46	4.68	4.59
MEANS	4.19	4.10	

An analysis revealed an interaction between quantifier and order. People were more likely to accept the diagram following "each" , "most", "every" and "several" sentences in which the universal quantifier occurred second. ($F1=2.54$, $df=6,660$; $p<.02$; $F2=64.17$, $df=6,414$; $p<.000001$). The analysis also showed an interaction between quantifier and diagram. People were more likely to accept the converging diagram following "some" , "several" and "many" sentences and the diverging diagram following "most", "all" , "every" and "each" sentences. ($F1=27.88$, $df=6,660$; $p<.000001$; $F2=63.65$, $df=6,414$; $p<.000001$).

Additional observations.

READING TIMES.

TABLE 8.6 MEAN READING TIMES (MSECS) FOR SENTENCES ACCORDING TO WORD ORDER.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEAN
Diagram Type			
DIVERGING	2008	2347	2177

An analysis revealed an effect of order. Reading time was faster for universal first sentences. ($F1=4.34, df=1,98$; $p <.04$; $F2=333.87$, $df=1,65$; $p <.000001$)

TABLE 8.7 MEAN READING TIME (MSECS) ACCORDING TO QUANTIFIER.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Condition			
some	2050	2282	2166
several	2156	2439	2297
many	1918	2417	2167
most	1940	2239	2089
all	2015	2468	2241
every	2013	2268	2140
each	1964	2314	2139
MEANS	2008	2347	

An analysis indicated no effect of quantifier.

EVALUATION TIME.

Prediction : faster evaluation time for universal **first sentences.**

TABLE 8.8 MEAN EVALUATION TIME (MSECS) FOR DIAGRAMS IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEAN
Diagram Type			
DIVERGING	1420	1617	1518

An analysis of variance indicated an effect of order in the predicted direction on F2 only; $F2=11.43$, $df=1,65$; $p <.002$; $F1=2.36$, $df=1,98$; $p <.1$).

Prediction : faster evaluation time according to Ioup's hierarchy.

TABLE 8.9 MEAN EVALUATION TIME (MSECS) ACCORDING TO QUANTIFIER.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Condition			
some	1744	1842	1793
several	1473	1654	1563
many	1522	1634	1578
most	1362	1658	1510
all	1295	1822	1558
every	1181	1303	1242
each	1364	1406	1385
MEANS	1420	1617	

An analysis of this data showed an effect of quantifier, $F1=8.42$, $df=6,588$; $p <.00001$; $F2=5.82$, $df=6,390$; $p <.00005$). Inspection of table 8.9 suggests that this is mainly due to "each" and "every" being faster and "some" slower.

Results from Experiment 8 provided some support for Johnson-Laird's word order hypothesis. Evaluation time data indicated faster evaluation times following universal first sentences, on F2 only. This result is in keeping with the word order hypothesis that proposes preference for the diverging diagram following universal first sentences. Reading time data indicated faster reading times for universal first sentences; this result suggests that people may compute the diverging interpretation as they read universal first sentences and so have a model of this interpretation available by the time the diagram appears. Data from diagram choice scores indicated an effect of word order consistent with Johnson-Laird's theory since the diverging reading was more popular following universal second sentences , though it should be noted that the diverging reading was more popular overall in this experiment.

Ioup's proposed hierarchy of quantifiers was supported by diagram acceptance data. More diverging diagrams were accepted as the hierarchy descended through "some", "several", "many", "most", "all", "every" and "each" though there was a slight deviation with "all" in both word order conditions; "all" had a lower mean score for diverging diagrams than "most". Though evaluation time data did not follow the proposed hierarchy so closely there was a strong effect of quantifier, with diagrams following "every" sentences being evaluated quickly. Reading time data did not show a quantifier effect.

One cannot be certain that scope assignments are already assembled by the diagram evaluation stage. The design of Experiment 8 forced people
to assign scope, at least by the diagram evaluation stage when they 2
were required to make a judgement about scope. The following

experiments, Experiments 9 & 10, concentrate on reading times for doubly quantified sentences followed by continuation sentences. It was expected that this strategy would avoid the problem of forcing people to make scope assignments. Reading times were examined on the assumption that scope effects would cause differences in reading times.

EXPERIMENT 9.

PRONOUN READING TIMES.

INTRODUCTION.

Experiment 9 signalled a departure from the strategy of asking subjects to evaluate a diagram following presentation of a doubly quantified sentence. The previous experimental strategy was useful for supplying information about the number of times subjects chose either a converging or a diverging diagram, but the experimenter decided to concentrate on reading times for the current experiment. It was expected that reading times would show the effects of scoping decisions; for example, if scope is assigned during reading the first (doubly quantified sentence) then it was expected that continuation sentences consistent with the scope assignment would result in faster reading times.

Experiment 9 investigated the effect of the individual characteristics of quantifiers and the effect of continuation sentences on scope. The effect of individual quantifiers was examined by including sentences which contained "some", "several", "many", "most", "all", "every" and "each", combined with "a". The continuation sentence variable was manipulated by following the doubly quantified sentence with a singular continuation (ie one that continued the converging interpretation for the doubly quantified sentence) or a plural continuation (ie one that continued the diverging interpretation for the doubly quantified sentence.) For the sake of clarity the singular continuation will be referred to as "converging" and the plural continuation will be referred to as "diverging". These manipulations gave sentence pairs like the following :

"Martin sold a book to some students.

They were pleased to buy it." (converging continuation)

"Martin sold a book to some students.

They were pleased to buy them." (diverging continuation)

Reading times for both the doubly quantified sentence and the continuation sentence were examined on the assumption that longer reading times reflected greater processing complexity for the comprehension system. It was expected that following sentences containing quantifiers which had been less likely to induce the diverging interpretation in Experiment 8, namely "some", "several" and "most", the singular continuation, representing the converging interpretation, would be read faster than the plural continuation. Conversely it was expected that plural continuations representing the diverging interpretation would be read faster following sentences containing quantifiers which had favoured the diverging interpretation, namely "many", "every" and "each", than singular continuations. In all cases the universal quantifier was Indirect Object. For the purposes of this experiment the term universal quantifier refers to the multiple quantifiers "some", "several", "most", "many", "all", "every" and "each". As in Experiment 8 "some" was treated as a universal quantifier. The design of the experiment ensured that it was possible to distinguish between the effects of the universal quantifiers, so that any differences between "some" and the other multiple quantifiers would be observable.

<u>Additional observations.</u>

Because the universal is Indirect Object in all cases Ioup would predict that subjects will show a preference for diverging interpretations. The design of Experiment 9 did not allow for the number of converging and diverging readings made to be measured, but the experiment did allow reading time to be measured. The experimenter expected that if the diverging reading is the preferred one for the sentences used in Experiment 9 then the diverging reading should be the easier to compute. If this is the case then diverging continuations should be read more quickly than converging continuations.

METHOD, EXPERIMENT 9.

SUBJECTS.

Seventy undergraduate and postgraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented singly using a BBC Master series microcomputer. There were fourteen experimental lists, each consisting of 70 sentences. Below are examples of sentences seen by subjects.

SET 1.

Condition : CONVERGING CONTINUATIONS.

Susan gave a recipe to some friends.

They were pleased to get it.

Malcolm passed a drink to several players.

They were surprised to get it.

Maisie returned a gift to many people.

They were shocked to get it.

Shirley wrote a report for most managers.

They were dissatisfied with it.

Philip requested a plan from all architects.

They were quick to supply it.

Emily wrote a script for every presenter.

They were eager to read it.

Melanie got a card from each traveller.

They remembered to send it.

SET 2.

Condition : DIVERGING CONTINUATIONS.

Susan gave a recipe to some friends.

They were pleased to get them.

Malcolm passed a drink to several players.

They were suprised to get them.

Maisie returned a gift to many people.

They were shocked to get them.

Shirley wrote a report for most managers.

They were dissatisfied with them.

Philip requested a plan from all architects.

They were quick to supply them.

Emily wrote a script for every presenter.

They were eager to read them.

Melanie got a card from each traveller.

They remembered to send them.

The universal was indirect object in both Set 1 and Set 2.

A complete list of experimental sentences appears in Appendix 9(a).

DESIGN.

Experiment 9 investigated two factors:

1. Quantifier : A with some, several, many, most, all, every and each.

2. Type of Continuation : converging vs diverging.

Each doubly quantified sentence type was followed by a sentence continuing the converging or the diverging interpretation for the sentence. This gave a total of 14 conditions. Fourteen experimental lists were prepared. The lists consisted of 70 sentences, five in each of the experimental conditions.

On the experimental lists , the first five examples of each quantifier were followed by a sentence continuing the converging interpretation for the doubly quantified sentence, and the second five examples of each quantifier were followed by a sentence continuing the diverging interpretation for the doubly quantified sentence. After each sentence pair subjects were required to answer a question about the sentences they had just seen. This question was always answerable "yes" or "no". The questions were included in order to prevent subjects from simply skimming the experimental sentences without reading them for meaning. Data from the response to questions was not analysed.

Lists were organised so that all the quantifer pairs (ie a / some, a / several, a / many, a / most, a / all, a / every,and a / each) appeared in each experimental sentence frame. This organisation ensured that all the experimental sentences appeared in each experimental condition.

Subjects also saw a list of filler sentences and questions consisting of assorted lexical material. An example is shown below :

"Paul walked behind Fiona and he was pleased to do so."

"Was Fiona in front of Paul ?"

The filler list was included in order to avoid subjects becoming too familiar with the doubly quantified sentence types. The filler sentence data was not used in the analysis of this experiment.Subjects also saw a practice list consisting of seven doubly quantified sentences and a number of other sentences . The order of presentation of the sentences was randomised by the computer, and halfway through the experiment there was a short rest period of two minutes duration. Subjects were assigned to lists by means of a matrix.

PROCEDURE.

Subjects were tested singly in a self-paced reading and evaluation task. They were given a typed sheet of instructions which read as follows:

"You will see a series of sentence pairs which will appear sentence by sentence on the computer screen. I would like you to read each sentence and press the space bar as soon as you have done so. After each sentence pair you will get a question relating to the sentences you have just read.The question is always answerable either "yes" or "no".

If you think the answer to the question is "yes" press the "YES" key.
If you think the answer is "no" press the "NO" key.

Work your way through the experiment as quickly as you can but make sure you understand the sentences you read. Half way through the experiment there will be a short rest period. There is a practice session first. Do you have any questions?".

The sentences were presented one at a time in normal case. Subjects were asked to press the space bar as soon as they had read the first sentence. This key press removed the doubly quantified sentence from the screen and one of the two continuation sentences,representing either the converging or the diverging interpretations for each sentence appeared on the screen. Subjects had to read this sentence and again press the space bar as soon as they had done so.

This second key press removed the continuation sentence from the screen and a question appeared. Subjects then had to press a key marked "YES" if they thought the answer to the question was "yes" or a key marked "NO" if they thought the answer to the question was "no". The key marked "NO" was at the letter "E" position on the keyboard (ie at the left-hand side of the keyboard), and the key marked "YES" was at the letter "I" position on the keyboard, (ie at the right-hand side of the keyboard). This key press removed the diagram from the screen and the next experimental sentence appeared.

Subjects were advised to keep their left hand positioned over the "NO" key and their right hand positioned over the "YES" key. They were also advised to use their thumbs to press the space bar. This method facilitated speed of response. Midway through the experiment there was a two minute rest period, signalled by the message "Short pause now, please wait" on the computer screen.At the end of this rest period the computer alerted the subject by producing a tone and the message "press space bar for next sentence" appeared on the screen.When the final sentence had been read and the last question answered the final key press caused the message "That's all thankyou. You can go now." to appear.

The experimenter remained with the subject for the duration of the practice list and was available to answer any questions. After the practice list was completed the subject was left alone to finish the experiment. Subjects normally took about twenty minutes to complete the experiment .

MEASURES.

The reading time for doubly quantified sentences in each experimental condition was measured. A measure of the time taken to read the continuation sentences was also recorded.

RESULTS AND DISCUSSION.

The overall results for Experiment 9 are shown below. The analysis tables for this experiment are in Appendices 9(b) and 9(c).

READING TIMES.

TABLE 9.1 MEAN READING TIME (MSECS) FOR DOUBLY QUANTIFIED SENTENCE IN EACH CONDITION.

Continuation Type	CON	DIV	MEANS
Sentence Type			
a..........some	1785	1881	1833
a.......several	1916	2033	1974
a..........many	1804	1891	1847
a..........most	1842	1932	1887
a...........all	1840	1825	1832
a.........every	1847	1847	1847
a..........each	1830	1819	1824
Means	1838	1890	

An analysis of variance compared reading times in each of the quantifier conditions. There was no effect of quantifier, F1=2.02, df=1,69; p<.06; F2=1.94, df=6, p<.07.

TABLE 9.2 MEAN READING TIME (MSECS) FOR CONTINUATION SENTENCE.

Continuation Type	CON	DIV	MEANS
Sentence Type			
a..........some	1069	1233	1151
a.......several	1076	1127	1101
a..........many	1070	1144	1107
a..........most	1051	1171	1111
a...........all	1074	1158	1116
a.........every	1126	1148	1137
a..........each	1096	1121	1108
Means	1080	1157	

An analysis of variance compared reading times for converging and diverging continuation sentences. There was an effect of continuation type. Reading times for the converging continuation were faster than reading times for the diverging continuation, $F1=25.42$, $df=1,69$; $p<.00004$; $F2=22.66$, $df=1,69$; $p<.00007$. There was no effect of quantifier, $F1<1$, $df=6$; $p<.56$; $F2<1$, $df=6$; $p<.58$. There was an interaction, on F1 only, between quantifier and continuation; $F1=2.19$, $df=6$; $p<.04$, $F2=1.78$, $df=6$, $p<.1$. Inspection of table 9.2 suggests that this is due to the quantifier "some".

Ioup's claims according to the grammatical function of the universal predict that since the universal is in indirect object position in both sets of materials the diverging reading will be preferred. The experimenter extrapolated from this that reading times would be faster for the diverging continuation. However, this prediction was directly contradicted; subjects were faster overall at reading sentences which continued the converging interpretation. There was also no effect of quantifier, though Ioup would claim that the individual characteristics of quantifiers should influence scope determination.

One possible explanation for these results is that subjects have not assigned scope at all, even by the end of the continuation sentence stage. One possible reason why the converging continuations are read faster is that the pronoun "it" attaches easily to the singular noun phrase (ie "a recipe") in the doubly quantified sentence.

If subjects have assigned scope, they may have given wide scope to "a" in every case. This is implausible since a single entity (eg "a recipe") cannot be given to more than one person at the same time. However, it may be the case that subjects treat a phrase like "some friends" as a single entity, ie one group.

One difficulty with this experiment is that the continuation sentence may itself be ambiguous. Consider, for example, the following:

"Susan gave some friends a recipe."

"They were pleased to get it./ They were pleased to get them."

In the continuation sentence "They" could conceivably refer to "friends" or "recipes", at least until the word "pleased" begins the process of disambiguation. (Pragmatically, recipes can't feel pleased). Taking this problem into account, reading times for the continuation sentences in this experiment maybe reflecting pronominal difficulties and not scope ambiguities.

For the final experiment, Experiment 10, the continuation sentences were altered to take account of this problem.

EXPERIMENT 10.

NOUN PHRASE READING TIMES.

INTRODUCTION.

Experiment 9 provided inconclusive results; the problem of ambiguity in the continuation sentences may account for these results. In Experiment 10 the experimenter eliminated the inherent ambiguity in continuation sentences by substituting Experiment 9 continuations for ones which clearly signalled a converging or a diverging interpretation of the doubly quantified sentence.

There were two types of continuation sentence; singular, corresponding to the converging reading for the doubly quantified sentence, and plural, corresponding to the diverging reading for the doubly quantified sentence. These manipulations gave rise to sentences like the following :

Condition : Universal 1st

Susan gave some friends a recipe.

Converging continuation : The recipe was for Hungarian Goulash.

Diverging continuation : The recipes were for different dishes.

Condition : Universal 2nd

Susan gave a recipe to some friends.

Converging continuation : The recipe was for Hungarian Goulash.

Diverging continuation : The recipes were for different dishes.

There are three possible strategies that subjects could use in disambiguating doubly quantifed sentences followed by continuation sentences illustrating one of the two possible interpretations. Firstly, they may compute all the possible interpretations for the doubly quantified sentence at once . Secondly, subjects may assign a default scope to the first sentence , which can be changed later in the light of subsequent information, ie the continuation sentence. Thirdly, subjects may not assign scope at all at the first sentence stage, but wait instead until the second sentence before determining an interpretation.

If all interpretations are computed at once then there should be no difference in mean reading times for the doubly quantified sentences or for continuation sentences. If people do assign "default" scope to the first sentence then there may be effects relating to word order as proposed by Johnson-Laird and Fodor, or relating to type of quantifier as proposed by Fodor and Ioup. Reading times for sentence 2, the continuation sentence, should reflect the scope given to sentence 1, the doubly quantified sentence. Therefore, if the continuation sentence is consistent with the scope assigned to the doubly quantified sentence then reading time should be fast. If the continuation sentence is inconsistent with the default scope then longer reading times should result.

Finally, if scope is not assigned during reading the doubly quantified sentence, but only when there is a need to disambiguate at the second sentence stage then there should be no reading time effects at the doubly quantified sentence stage, but effects should be noticed in reading times for the continuation sentences.

METHOD, EXPERIMENT 10.

SUBJECTS.

One hundred and forty undergraduate and postgraduate students from the University of Durham took part in the experiment. None had had tuition in Logic or Linguistics.

MATERIALS.

Sentences were presented singly using a BBC Master series microcomputer. There were twenty eight experimental lists, each consisting of 70 sentences. Below are examples of sentences seen by subjects.

SET 1

Condition : UNIVERSAL FIRST, CONVERGING CONTINUATIONS.

Susan gave some friends a recipe.

The recipe was for Hungarian Goulash.

Christine threw several children a frisbee.

The frisbee was bright red plastic.

Maisie left many people a gift.

The gift was not very suitable.

Eleanor threw most batsmen a ball.

The ball was far too soft.

Katie made all members a mascot.

The mascot was made from wood.

Fiona left every policeman a reward.

The reward was presented in public.

Melanie sent each traveller a postcard.

The postcard was late in arriving.

SET 2

Condition : UNIVERSAL FIRST, DIVERGING CONTINUATIONS.

Simon gave some girls a sweet.

The sweets were wrapped in paper.

Paul wrote several secretaries a memo.

The memos were varying in tone.

David delivered a lecture to many scholars.

The lectures were on diverse topics.

Jeff loaned most guests a key.

The keys were for the bedrooms.

Ann gave all boys a reprimand.

The reprimands were for different offences.

Antony drew all planners a diagram.

The diagrams were for contrasting designs.

Joe set each pupil a project.

The projects were handed in separately.

SET 3

Condition : UNIVERSAL SECOND, CONVERGING CONTINUATIONS.

Susan gave a recipe to some friends.

The recipe was for Hungarian Goulash.

Christine threw a frisbee to several children.

The frisbee was bright red plastic.

Maisie left a gift for many people.

The gift was not very suitable.

Eleanor threw a ball to most batsmen.

The ball was far too soft.

Katie made a mascot for all members.

The mascot was made from wood.

Fiona left a reward for every policeman.

The reward was presented in public.

Melanie sent a postcard to each traveller.

The postcard was late in arriving.

SET 4

Condition : UNIVERSAL SECOND, DIVERGING CONTINUATIONS.

Simon gave a sweet to some girls.

The sweets were wrapped in paper.

Paul wrote a memo to several secretaries.

The memos were varying in tone.

David delivered a lecture to many scholars.

The lectures were on diverse topics.

Jeff loaned a key to most guests.

The keys were for the bedrooms.

Ann gave a reprimand to all boys.

The reprimands were for different offences.

Antony drew a diagram for all planners.

The diagrams were for contrasting designs.

Joe set a project for each pupil.

The projects were handed in separately.

The universal was indirect object in all lists.

A complete list of experimental sentences appears in Appendix 10(a).

DESIGN.

Experiment 10 investigated three factors:

1. Word order : Universal quantifier 1st vs Universal quantifier 2nd.
2. Quantifier : A with some, several, many, most, all, every and each.
3. Type of Continuation : converging vs diverging.

The seven quantifier pairs appeared in either universal 1st or universal 2nd word order, giving fourteen experimental conditions. Each of these sentences was followed either by a converging or a diverging continuation. This gave a total of 28 conditions. Twenty eight experimental lists were prepared; each list consisted of 70 sentences.

On experimental lists 1-14 the universal quantifier occurred in first position. On experimental lists 15-28 the universal quantifier occurred in second position.On each list the first five examples of each quantifier were followed by a sentence continuing the converging interpretation for the doubly quantified sentence, and the second five examples of each quantifier were followed by a sentence continuing the diverging interpretation for the doubly quantified sentence. After each sentence pair subjects were required to answer a question about the sentences they had just seen. This question was always answerable "yes" or "no". The questions were included in order to prevent subjects from simply skimming the experimental sentences without reading them for meaning. Data from the response to questions was not analysed.

Lists were organised so that all the quantifer pairs (ie a / some, a / several, a / many, a / most, a / all, a / every,and a / each) appeared in each experimental sentence frame.This organisation ensured that all the experimental sentences appeared in each experimental condition.

Subjects also saw a list of filler sentences consisting of assorted lexical material followed by a question. An example is :

"Claire lived in Ealing, Harry lived in Putney. Lots of people commuted to London. Claire and Harry caught the tube and they were sick of the delays.

Were Claire and Harry patient people ? "

The filler list was included in order to avoid subjects becoming too familiar with the doubly quantified sentence types. The filler sentence data was not used in the analysis of this experiment.Subjects also saw a practice list consisting of fourteen doubly quantified sentences and a number of filler sentences . The order of presentation of the sentences was randomised by the computer.

Subjects were assigned to lists by means of a matrix .

PROCEDURE.

Procedure for Experiment 10 was identical to that of Experiment 9.

MEASURES.

The reading time for doubly quantified sentences in each experimental condition was measured. A measure of the time taken to read the continuation sentences was also recorded.

RESULTS AND DISCUSSION.

The overall results for Experiment 10 are shown below. The analysis tables for this experiment are in Appendices 10(b) and 10(c).

READING TIMES.

TABLE 10.1 MEAN READING TIME (MSECS) FOR DOUBLY QUANTIFIED SENTENCE IN EACH CONDITION.

Sentence Type	U 1st	U 2nd	MEANS
Quantifiers			
a..........some	1860	2228	2044
a.......several	2041	2354	2197
a..........many	1919	2251	2085
a..........most	1948	2262	2105
a...........all	1845	2124	1984
a.........every	1902	2173	2037
a..........each	1869	2190	2029
MEANS	1912	2226	

An analysis of variance was carried out on the data. The analysis indicated an effect of order; reading time was faster with universal first sentences, ($F1=5.21$, $df=1,138$; $p<.022$; $F2=162.88$, $df=1,69$; $p<.000001$). The analysis also showed an effect of quantifier; ($F1=7.38$, $df=6,828$; $p<.00001$; $F2=3.05$, $df=1,69$; $p<.006$). Inspection of table 10.1 suggests that "all" sentences had faster reading times than the other quantifiers. There were no other significant results.

TABLE 10.2 MEAN READING TIME (MSECS) FOR CONTINUATION SENTENCE.

Continuation Type	CON	DIV	MEANS
Sentence Type			
Quantifiers			
a..........some	1354	1498	1426
a.......several	1405	1448	1426
a..........many	1401	1484	1442
a..........most	1390	1455	1422
a...........all	1400	1463	1431
a.........every	1418	1426	1422
a..........each	1376	1432	1404
Means	1392	1458	

An analysis of variance was carried out on the reading time data for the continuation sentence. The analysis indicated an effect of continuation; the singular continuation (representing the converging reading) was read faster, ($F1=31.20$, $df=1,138$; $p<.0001$; $F2=8.39$, $df=1,69$; $p<.005$). There was also an effect to order on F2 only; reading time for the continuation sentence was faster following universal second sentences, ($F2=13.05$, $df=1,69$; $p<.0009$; $F1<1, df=1,138$; $p<.56$).

Reading time data for the doubly quantified sentences showed that people read universal first sentences faster. There was also an effect of quantifier; "all" sentences were read faster than sentences containing other quantifiers. These data suggest that universal first sentences and "all" sentences are easier to understand.

However, reading time data for the second sentence shows that in every case the converging continuation is read faster; this is especially the case following universal second sentences. Given the results for the second sentence it seems likely that the the converging interpretation is easier to make and that any continuation sentence consistent with this will be read faster.

Despite the ease with which universal first sentences are read, it seems that people are quite happy to assign a default scope to doubly quantified sentences, the default unexpectedly being the converging reading, which can be modified later if necessary. The fact that people seem to use the converging interpretation as the default option contradicts Fodor. She believes that people set up a skeleton representation when they first encounter a universal. The skeleton representation makes use of a "ditto" strategy by which only a single entity is fully represented; other paths are left open to be modified if necessary in the light of subsequent information. If subsequent information specifies the diverging reading then the skeleton representation plus its "ditto" notation will suffice and there is no psychological cost. If the converging reading is specified then the initial representation must be modified, resulting in longer processing time. Results from Experiment 10, however, suggest that the converging interpretation is more readily computed.

DISCUSSION OF EXPERIMENTS 8, 9 & 10.

The most striking result from this set of experiments is the effect of task. In Experiment 8, where the experimenter made sure that people had assigned scope, at least by the diagram evaluation stage, it was found that the diverging interpretation was the most popular. In Experiments 9 & 10, where the strategy of forcing scope assignment was not employed, it was found that the converging reading was the most popular.

What seems to be happening here is that in Experiments 9 & 10 (though Experiment 9 suffered from methodological problems which have already been covered) people are not setting up a complete representation of the doubly quantified sentences but are instead assigning the converging interpretation to these sentences by default. It is psychologically costly to modify the default scope and so people stick to their original interpretation; the converging reading.

One difference caused by the contrast in design between Experiment 8 and Experiments 9 & 10 is that in Experiment 8 people have to change a propositional representation, the sentence, into a mental model which is completely analogical, in order to evaluate the diagram. There is no such requirement in Experiments 9 & 10, where a propositional representation will suffice when the second stage of the experiment, ie the continuation sentence, is encountered. There is evidence for a distinction between propositional representations and mental models. Mani and Johnson-Laird (1982) found that if people were given descriptions that were either determinate or indeterminate they would build a model of the determinate description yet fail to build a model of the indeterminate description because it was compatible with more than one model.

The last set of experiments show support for this finding. In Experiment 8, though initially people may not establish a model identifying scope, they are forced to do so at the diagram evaluation stage. In Experiments 9 & 10 the indeterminate propositional representation does not need to be modified following presentation of the second sentence; people are simply required to read the second sentence and there is no need to make a judgement about it. Results from the final set of Experiments suggest, therefore, that people do not fully disambiguate scoping decisions until this is made necessary by later tasks.

CHAPTER 5, DISCUSSION.

PART 1. Specific predictions about quantifiers.

It will be useful at this point to draw together the results of the experiments reported in the thesis and to examine how well they support the specific predictions made regarding the comprehension of quantified sentences. The thesis has investigated three main strands : the effect of word order, the effect of the grammatical function of the universal quantifier, and the effect of characteristics of individual quantifiers in determining quantifier scope.

1.1 Word Order.

To recap briefly, the word order hypothesis proposed by Johnson-Laird holds that if a universal is first quantifier in a sentence then the diverging reading will result, and if the existential is first quantifier then the converging reading will result. Strong support for this hypothesis was found in Experiments 1 & 2, but since the variables of voice and order were confounded in this experiment the result may not be reliable. However, Experiment 3 which avoided the voice / order problem showed full support for Johnson-Laird's theory. Experiments 1,2 and 3 were drawing tasks which required people to illustrate a representation of a doubly quantified sentence. Later experiments involving diagram judgements also supported the word order hypothesis. Experiment 6 showed that more converging diagrams were accepted (indicating that the converging reading had been made) when the existential was first quantifier. Results from Experiment 7 followed a similar pattern, providing further support for the word order hypothesis.

However, there was some dissent. Experiment 4 and Experiment 5 were "subject / predicate evaluation" experiments,and used only active sentences, thereby overcoming the voice / order problem. These experiments did not show a word order effect.

In Experiments 4 and 5 people had to choose between two diagrams and there was no significant difference between scores for the converging and diverging diagrams. One problem with the strategy of asking people to choose between two diagrams representing the converging and the diverging readings is that of necessity one diagram must be rejected, despite the fact that under other circumstances (ie if the diagram types were presented alone) people might find both diagram types perfectly acceptable for the same sentence structure. Experiment 6 and Experiment 7 gave people the opportunity to accept either diagram by presenting the converging and diverging diagrams singly; this meant that it was possible for people to accept both diagrams for the same sentence type. This strategy avoided placing people in a forced-choice situation . It was found that results from Experiments 6 and 7 showed some support for the word order hypothesis. Experiment 8 involved the presentation of single diagrams following dative sentence constructions and provided some support for Johnson-Laird's view.

Data from evaluation times showed a hint of support for the word order theory. Data from Experiment 4 suggested that evaluation time for the converging diagram is faster following sentences in which "a" was the first quantifier, and faster for the diverging diagram following sentences in which "a" was the second quantifier, but the data is not clear cut. (This result refers to "a /every" sentences only). Experiment 5 showed faster reading times for the diverging diagram, especially following universal first sentences, and this result was repeated for Experiment 8. Results from Experiments 6 indicated that evaluation time for the converging diagram was faster following universal second sentences but there was no effect of order in the evaluation time data for Experiment 7.

Given the fact that results indicate only patchy support for Johnson-Laird's word order hypothesis it seems likely that other factors apart from word order affect scoping decisions, though the support found for word order in Experiments 1, 3, 6 and 7 means that word order does play a role in determining quantifier scope. It seems likely that the strong effect of word order Johnson-Laird found with the matrix task (Johnson-Laird, 1969) was task dependent. Support for the word order theory is variable with the experimental material used in this thesis, and although word order cannot be ruled out an investigation of other factors is necessary. The experimenter suggests that the factors which mediate the effect of word order are context and general knowledge; an argument for this position will be taken up in Part 3 of the Discussion section.

1.2 Grammatical Function.

I turn now to an examination of the effect of the grammatical function of the universal. Experiments 6 and 7 show only limited support for Ioup's claims that the converging reading should be preferred when the universal is deep object and surface object. The data is in the predicted direction but is not significant. This prediction is consistent with the word order hypothesis too and so it is not possible to distinguish the effect of grammatical function and the effect of word order on the basis of the data since both theories predict the same result. It is possible, however, that an interaction may occur between word order and grammatical function.

Kempson and Cormack argue that the topic occupies the leftmost quantified phrase in a sentence, corresponding to the leftmost quantified set of the logical form of a proposition (Kempson & Cormack, 1981). Kempson and Cormack point out that when active sentences and their correlative passives are used the first noun phrase of the passive sentence becomes the topic of the sentence. According to Ioup's hierarchy of grammatical function the topic is most likely to take dominant scope over the other grammatical positions. However, no effects of grammatical function were noted in the results from Experiments 6 & 7 which used active and passive sentences, and so it is not possible to make claims for the supremacy on the hierarchy of the topic position.

Experiments 6 and 7 examined only a few of the grammatical postions Ioup includes in her hierarchy. A further grammatical position was investigated in Experiment 8. Experiment 8 utilised dative constructions followed by a diagram evaluation task in an experiment designed to test Ioup's hierarchy of quantifiers, (not of grammatical function), and in this case the universal was always in indirect object position. Indirect object position occurs at the fourth point on Ioup's hierarchy of grammatical function. At this position the universal is still likely to induce the diverging reading , though not so likely as if it was , for example, topic or deep and surface subject. The design of the experiment meant that a comparison between the effect of word order and the effect of grammatical function could be made, since word order altered but grammatical function did not. Results from Experiment 8 indicated that the diverging reading was the most popular choice for subjects, a finding which shows some support for Ioup's hierarchy of grammatical function.

Experiments 9 and 10 also used dative constructions but these were followed by continuation sentences which corresponded either to the converging or the diverging interpretation. The universal was indirect object in both experiments. Data from Experiment 9 indicated a lack of support for the grammatical function hypothesis, since in all cases the converging continuation was read more quickly. This result is not predicted when the universal quantifier is indirect object; in this position the diverging reading should be facilitated. However as noted earlier the design of Experiment 9 meant that reading times could be reflecting pronominal confusion rather than scope ambiguity and so it is necessary to exercise caution in interpreting the results from this experiment.

Ioup's views on grammatical function were not well supported by data from the thesis,which examined the grammatical function of the universal in all experiments, but it would be useful to look at the full range of grammatical functions which Ioup places on her hierarchy in future experiments.

1.3 The characteristics of individual quantifiers.

Further predictions were made regarding the inherent characteristics of individual quantifiers. Both Fodor and Ioup predicted that "every" would result in more diverging readings than "all". Ioup also establishes a hierarchy of quantifier scope which is detailed elsewhere in the thesis. The hierarchy ranges from "each" which has the greatest tendency towards highest scope to "a few" which has least tendency towards highest scope.The prediction that "every" would cause more diverging readings than "all" was strongly supported by results from the first three experiments, but later experiments did not show this pattern of results. Since Experiments 1, 2 & 3 were the only experiments where people had to illustrate a representation of the doubly quantified sentence it seems likely that the result is task-specific. For example, in Experiments 4 & 5, diagram evaluation experiments, the opposite result was found and "all" had more diverging readings than "every".

Ioup's hierarchy of quantifiers was examined in Experiment 8. In every case, except for a minor fluctuation with "all", Ioup's hierarchy was supported. "Some" resulted in very few diverging representations and the number of diverging readings increased as the hierarchy descended through "several", "many", "most", "all", "every" and "each". This pattern held regardless of word order. Ioup believes that set size determines the position of a quantifier on the hierarchy; the larger the set identified by a quantifier the higher on the hierarchy the quantifier is likely to be and the more likely it is to take wide scope.

Reading time data from Experiment 10 indicated that "all" sentences were read faster. One possible explanation for this is that "all" is easier to comprehend than the other quantifiers because it has a simpler representation. Newstead states that "all" is relatively simple when represented via Euler circles (Newstead, 1990, personal communication). However, Experiment 8 showed faster evaluation times following "each" and "every" sentences. Intuitively it seems that quantifiers like "several" and "many" have a less well specified meaning than the other quantifiers used in Experiment 8. It is not surprising then that multiple quantifiers which are less vague , for example "all", "each" and "every" result in faster reading and evaluation times.

To summarise this section , there is support for the views that word order and the individual characteristics of quantifiers affect scoping decisions. Support for the word order hypothesis is not consistent, which suggests that word order alone cannot determine scope. There is strong support for Ioup's hierarchy of quantifier scope indicating that the semantics of quantifiers is an important tool for reaching scoping decisions. The theory of grammatical function is not substantiated, though this topic would bear further research.

PART 2. Mental Models.

In Johnson-Laird's view the most salient feature of a coherent discourse is that it must be possible to construct a single mental model from it. A mental model sets up a mental description of events, and the meaning of a sentence will depend crucially on the mental model established for the sentence.

One of the investigative strands of the thesis was to look at how successful the theory of Mental Models is in accounting for the comprehension of doubly quantified sentences. Obviously the main question is, therefore, whether people set up a mental model of the doubly quantified sentences. The experiments most directly relevant to this question are the later ones, Experiments 8, 9 and 10.

These three experiments followed the strategy of presenting a doubly quantified sentence first in order to provide context for the second part of the experimental design. In Experiment 8 the first (context) sentence was followed by a diagram which people had to evaluate. The diagram represented either the converging or the diverging interpretation for the first sentence. In Experiments 9 and 10 the first sentence was followed by a second (continuation) sentence which corresponded either to the converging reading or the diverging reading for the first sentence. People were asked to read the second sentence and no scoping decision was formally required from them.

There are three possible strategies that people could use when they encounter either the context / continuation sentence pairs or the context / diagram pairs. Firstly they may compute all the possible interpretations for the context sentence immediately. Secondly they may assign a "default" scope to the context sentence which can be altered later if subsequent information makes this necessary. Finally people may not assign scope until the second stage (ie the presentation of the diagram or the continuation sentence) before deciding on an interpretation.

If all interpretations are computed at once then there should be no difference in reading times for first (context) and second (continuation) sentences. If people assign a default scope to the first sentence then reading times for the second sentence (or evaluation times for the diagram) should reflect the scope given to the first sentence. Therefore, if the second sentence or the diagram is consistent with the scope given to the first sentence then reading or evaluation time should be fast. If the second sentence is inconsistent with the default scope then longer reading and evaluation times should result. Finally, if people delay making scope assignments until the diagram or second sentence stage there should be no effects at the first sentence stage but effects should be seen at the second stage.

Results from Experiment 9 showed no significant effects in either first or second sentence reading times. However, the materials used for Experiment 9 were similar to the following :

Susan gave a recipe to some friends.

They were pleased to get it.

and as pointed out elsewhere it was felt that this type of construction might lead to results which reflected pronominal difficulties rather than differences in scope. (For example, "they" could conceivably refer to "recipes" or "friends", at least early in the comprehension process).

For Experiment 10, results indicated that reading time for the first sentence was faster for universal first sentences and for sentences containing "all". Reading time for the second sentence was faster for the singular continuation regardless of which quantifier appeared in the first sentence. There was also a hint that second sentences were read faster following universal second sentences. It seems that the converging interpretation is preferred regardless of quantifier and also regardless of word order; universal first sentences should lead to the diverging reading. However the hint of faster reading times for the second sentence following universal second sentences does provide a little support for the word order hypothesis and also for the theory that a default scope (in this case the converging interpretation) is assigned during the first sentence.

One problem with the conclusion that the converging reading is the preferred one is the faster reading times associated with "all", which should lead to the diverging interpretation. One solution to this problem is that "all" has a relatively simple representation and is comprehended more quickly because of this. A second problem with this conclusion is the faster reading times for universal first sentences which should facilitate the diverging reading. Results from Experiment 10 are problematic for the views of Fodor and Johnson-Laird, who both propose that the earlier a quantifier occurs in a sentence the more likely it is to take wide scope over other quantifiers in the sentence. Experiment 10 indicated that people show a strong preference for the converging continuation (it has faster reading times than the diverging continuation) despite the fact that universal first sentences, which according to all the theories discussed should lead to the diverging interpretation, are computed more quickly as evidenced by the reading time data. One explanation of these findings is that people have not assigned scope even by the end of the second sentence. They may have set up a weakly specified model of the first sentence but since subsequent information does not require full scope disambiguation (ie for inference tasks) a simple propositional model of the sentence is adequate. Indeed it would be psychologically extravagant to compute a complete mental model at this stage if only some of the information contained in the model will be needed.

In Experiment 8 an effect of order was found in the first sentence reading times. Reading time was faster for universal first sentences, as in Experiment 10. There was a hint in the data that diagram evaluation time was faster for the diverging diagram after universal first context sentences. An analysis of diagram choice data suggested that the converging interpretation was computed during reading the first sentence as default scope for the sentence. This suggests that the default scope is modified at the diagram evaluation stage when a definite decision must be made regarding scope. At this stage the diverging interpretation is preferred.

The differences observed between Experiments 8, 9 and 10 are likely to be task dependent. In Experiment 8 people were forced to assign scope at the diagram evaluation stage and they needed a complete mental model in order to do this. It would be sensible for people to delay setting up a mental model until the evaluation task since it is only at this stage that a fully fleshed out model is required. It seems likely, therefore, that unless a task is subsequently encountered that makes disambiguation imperative people do not process doubly quantified sentences to the stage of constructing a whole mental model but make do with an unfinished representation. Results from earlier experiments also support this claim. Faster evaluation times were found for the diverging diagram in Experiments 4 & 5 which required subjects to disambiguate scope by asking them to make a decision about a diagram. The question of which experimental task is closer to "natural" comprehension is debatable but it seems probable that the context / continuation sentence pairs are closer to the sort of tasks people usually encounter in reading text.

Findings from Experiments 8, 9 and 10 substantiate claims made by Johnson-Laird which suggest that comprehension takes place in two stages. His research with Mani (Mani & Johnson-Laird, 1982) on memory for spatial images led him to conclude that the first stage of comprehension is merely the superficial understanding of a sentence, for which a propositional representation will be adequate. The second stage of comprehension is (crucially for the theory) optional. It is at this stage that propositional representations are used to form a mental model of the situation described in the sentence. It seems likely that in the context / continuation experiments included in the thesis the optional stage of creating a mental model from a propositional representation is omitted. Only in the context / diagram experiment, where people must make a decision about the doubly quantified sentence is the second stage of comprehension completed.

Johnson-Laird, Byrne & Tabosssi (1989) have postulated a model to account for the comprehension of doubly quantified sentences. Their theory describes how a model of a multiply quantified sentence can be assembled. They describe the comprehension process itself; any reasoning tasks which follow from this process depend simply on formulating conclusions from the model and searching for counter examples.

As detailed earlier in the thesis Johnson-Laird et al explain that building a model of a multiply quantified sentence depends primarily on the meaning of the quantifiers contained in the sentence. Furthermore, their model must be capable of accomodating any number of quantifiers in a particular sentence. They assume that comprehending quantified sentences takes place according to a rule-by-rule process by which for any syntactic rule "there is a structural semantic principle for assembling the semantic representation that will guide the construction of models". (Johnson-Laird, Byrne & Tabossi, p.669).

The meaning of a quantifier is the basis for a loop that is used in the model building and evaluating program. For example, the universal quantifier "all" needs a loop that constructs relationships for every member of an arbitrarily sized set, whereas the existential quantifier "some" needs a loop that constructs relationships for an arbitrary number of entities in a set. If a universal quantifier is encountered first in a sentence then a loop (Loop A) will select a nominally sized set of entities. If an existential quantifier is subsequently encountered in the sentence a second loop (Loop B) establishes a set of entities and selects an arbitrary number of members from it. The task of Loop A is now to satisfy a relation between every member of its set and a member of the set belonging to Loop B; the task of Loop B is to satisfy a relation between an arbitrary number of entities in its set and a member of the set belonging to Loop A.

According to Johnson-Laird et al, the order in which the loops operate depends upon the scope of the quantifiers. The first loop corresponds to the quantified phrase with the largest scope, the second loop to the quantified phrase with the next largest scope and so on. The program thus allows for scope ambiguities and assumes their existence. Johnson-Laird et al do not specify how scope is disambiguated, but it would be plausible to presume that it is at this point that the "structural semantic principle" associated with any syntactic rule would be utilised in order to at least begin the process of assigning scope to the quantified phrases. For example, Johnson-Laird et al claim that the meaning of a quantifier provides the "raw material" for the model building process; because the meaning of "every" entails that a relationship must be identified for each member of its set,then "every" will usually be given highest scope in a doubly quantified sentence.

Once the model is constructed Johnson-Laird et al propose that the procedure for formulating conclusions begins. The procedure halts with the strongest conclusion that holds over all models of the premises and will respond "no valid conclusion" if a description holding across all models is absent. It is reasonable to assume that mistakes in comprehension arise either from faulty construction of the model or from errors in the checking procedure. It is important to note that Johnson-Laird et al's findings are based on research into reasoning with quantifiers where people are required to reach a decision about quantified syllogisms. The model can be useful, however , as a tool for explaining the comprehension process which occurs in the context /

evaluation experiments described in this thesis, which require that a scoping decision be made.

Johnson-Laird et al reject the hypothesis that once the stage of evaluating models is reached people use formal rules to make inferences on the basis that such a strategy is impoverished in comparison with the potent semantic information people have at their disposal. Instead of using a formal rule-based system for formulating conclusions Johnson-Laird et al propose that at this second stage of comprehension contextual clues and inferences based on general knowledge help to evaluate the models. Hence both semantics and pragmatics are involved in evaluating a mental model. Context and pragmatics are useful heuristic strategies to use in comprehension since they determine what is plausible. It is with the effect of context and general knowledge that the next section is concerned.

PART 3. Quantifiers and Pragmatic Factors.

3.1 Quantifiers and Context.

The effect of context on text comprehension has been well documented in recent years (see for example Bransford & McCarrell, 1977; Crain & Steedman, 1985; Altmann & Steedman, 1988; with quantifiers, Newstead, 1988).

These researchers have in common a belief that context and general knowledge aid comprehension and disambiguate sentences and passages of text. Because the meaning of a word alters according to the context in which it is used (for example placing a photograph in an album requires fine dexterity whereas placing a large framed photograph in a gallery requires a different interpretation of the word "place"), the task of a reader or listener is to select the appropriate situations which would ensure that the truth value of the sentence being comprehended is maintained.

As Bransford & McCarrell point out , not only can a single word be interpreted differently according to the context of the sentence in which it is heard, but a complete sentence may be understood differently according to the wider context in which it is set (Bransford & McCarrell, 1977). They cite the following investigation as evidence. One group of subjects heard this passage:

"The man was worried. His car came to a halt and he was all alone. It was extremely dark and cold. The man took off his overcoat, rolled down the window and got out of the car as quickly as possible. Then he used all his strength to move as fast as he could. He was relieved when he finally saw the lights of the city, even though they were far away."

(Bransford & McCarrell, 1977).

Immediately after hearing the passage subjects were asked 1) Why did he take off his overcoat ? and 2) Why did he roll down the window ? Not surprisingly subjects were slow to respond and hesitant in giving their answers. A second set of subjects were tested with the passage but this time the second sentence was subtly altered to:

"His submerged car came to a halt."

Subjects from the second group were able to answer the questions quickly and confidently. According to Bransford and McCarrell, subjects in the first group comprehended the relations between the man, the coat and the window merely as ones of temporal succession. Subjects in the second group had a much richer context with which to facilitate their comprehension of the passage. They were able to infer that the car, the man and the coat were below water and so understood why the man removed his overcoat (to allow him to swim) and subsequently rolled down the window (to swim out of the car).

Evidence to support the view that quantifiers are given a different interpretation according to the context in which they occur is cited by Newstead (Newstead, 1988). As noted in the Introduction section Newstead reported an experiment by Pepper and Prytulak which found that the quantifier "frequently" was interpreted as meaning 70% of the time when used in the context of males finding Miss Sweden attractive, but only as 20% of the time when used in the context of the incidence of airplane accidents. Given this finding it is likely that the experimental sentences used in experiments described in this thesis unavoidably contained context effects. To cite just one example, the noun phrase "some photographs" intuitively seems to indicate a larger number than the noun phrase "some flats", though both contain the same quantifier. Informal enquiries with a number of respondents support this claim.

The individual characteristics (semantics) of quantifiers mean that different quantifiers identify sets of different sizes; for example "some" identifies a smaller proportion than "every". Ioup proposes a hierarchy of quantifiers largely based on set size. The bigger the set identified by a particular quantifier the higher on the hierarchy the quantifier is likely to be and the more likely the quantifier is to take wide scope. This prediction was substantiated by results from Experiment 8, where dative constructions were followed by an evaluation task.

However, it is unlikely that set size remains constant in different contexts. Hormann (1983) has identified four factors which affect set size and hence alter the interpretation people give to quantifiers. These factors are object described, size of object, spatial location and field of vision; to sample the effect of object described one has only to note that a few crumbs suggests a larger number than a few mountains. In this respect again my earlier example contrasting the idea of number invoked by "some photographs" and "some flats" suggests that the interpretation of "some" is variable according to sentence context, and it is logical to assume that this phenomenon holds with other quantifiers. As a further example the following two sentences illustrate the effect of spatial location :

"Many cars were parked in front of the house."

"Many cars were parked in front of the stadium."

In the first sentence the number of cars indicated is a lower figure than than the number indicated in the second sentence; thus the size of the set described by the quantifier "many" has altered.

3.2 Quantifiers and General Knowledge.

Care must be taken not to confuse context with the effect of general knowledge. General knowledge refers to the background information a person has when he or she encounters a sentence, for example the knowledge that birds fly or that wood floats on water. The effect of general knowledge on the interpretation of experimental sentences used in this thesis cannot be discounted. One strong example of a sentence involving the use of general knowledge is the following :

"A president defeats all senators".

This sentence was not used after its inclusion in early experiments because it was thought likely that people would have sufficient information available from general knowledge to indicate that at any one time there can only be one President, whereas there can be many senators. To borrow a phrase from Sanford and Moxey, the effect of general knowledge in this instance would be to decide what is "in focus",ie to determine what is in the mental model. According to Crain and Steedman general knowledge would help to determine what syntactic elements were proposed for selection by the sentence processor and in this instance it would be logical for the reader to assume the existence of only one president and give "a" wide scope.

One problem that arises in considering the experimental sentences is that it is impossible to distinguish between interpretations involving separate entities and interpretations involving multiple identical copies of the same entity. An example should clarify this point. Consider the sentence :

"Susan gave a recipe to some friends".

The following interpretations are possible:

1. Susan gave a single recipe to a set of friends.
2. Susan gave a different recipe to each member of the set of friends.
3. Susan gave a copy of the same recipe to each member of the set of friends.

In 1. "a" has highest scope. In 2. & 3. "some" has highest scope but it is not possible to judge between the two candidiate interpretations. Indeed for most purposes it would be unnecessary to decide between the two unless later inference tasks required a decision. To further complicate matters a fourth interpretation is possible, ie that Susan gave the same recipe to the friends on different occasions.

In some instances general knowledge can solve problems of this nature. For example there are two candidate interpretations for the following sentence :

"Neil rented a flat to some students".

The probable interpretations are :

1. Neil rented a single flat to a set of students.

2. Neil rented a separate flat to each member of the set of students.

General knowledge allows us to decide that it would be implausible to postulate multiple copies of the same flat in the interpretation of this sentence and thus the number of interpretations that can plausibly be made is reduced. A third interpretation, that Neil rented the same flat on different occasions is also possible and general knowledge tells us that this is a plausible alternative.

Given the weight of evidence for the effect of context and general knowledge on the comprehension of text and single sentences it is hardly surprising that any model of quantifier comprehension must allow for these factors. Johnson-Laird et al's model of the comprehension of quantified sentences is appealing because it includes recourse to context and general knowledge as a means of evaluating putative models.

Because Johnson-Laird et al's model proposes that the order in which the loops cycle is determined by the quantified phrase with highest scope it assumes that scope does not begin to be assigned until the whole sentence is read (though how scope is assigned is not well-specified; however Johnson-Laird et al do state that the meaning of a quantifier is crucial for the model building and evaluating process). Fodor believes that schematic representations (mental models) are begun as soon as the first quantifier is encountered. It would make sense to delay processing the sentence until it is available for comprehension in its entirety, since any modification to an initial representation will prove psychologically expensive. Fodor proposes that in the case of spoken sentences a prosodic contour is used which encourages listeners to delay processing a sentence until the final quantifier has been heard; this would avoid costly backtracking for the comprehension system.

To conclude this section , the effect of context and general knowledge, though not investigated as experimental variables, cannot be ignored. Any sentence provides its reader or listener with a context ranging from rich to poor and it is impossible to provide people with context free experimental material. Similarly it is not possible (nor desirable!) to exclude the effect of general knowledge on comprehension.

Part 4. Towards a model of quantifier comprehension.

This section contains some tentative proposals to account for the way in which doubly quantified sentences are processed. Experiments described in the thesis indicated that the word order effect was often strong. This finding suggests that people begin to set up a model as soon as the first quantifier in a sentence is encountered. But other factors appear to modify this effect; in particular the inherent characteristics (the meaning) of individual quantifiers bias people quite strongly towards a particular reading. What may be happening is that the strongest initial influence on scope assignment is word order in line with Johnson-Laird's theory, but that subsequent information from the second quantified phrase can cause scope reassignment. Also relevant to scoping decisions is the context in which a quantifier occurs, either the noun the quantifier is associated with or the sentence frame as a whole. This would be in keeping with the views of Newstead who states categorically that quantifiers do not have a fixed meaning but that their meaning is flexible according to the environment in which they occur.

It seems plausible to suggest that when people encounter the first quantified phrase in a sentence they set up an initial representation containing only a single entity . For example with the sentence :

"All the girls ate a cake"

the initial representation would be very simple:

g----

where "----" is a notation indicating an expected relation between the entity in the model and another constituent in the sentence. Once this is done the next portion of the sentence can be processed. It would make sense for a person to process the sentence section by section if only the barest representation is set up; to do more than this may result in expensive backtracking once the whole sentence is read, and provided backtracking is not necessary it is quicker to process in sections rather than to delay processing until the sentence is complete. When the next quantified noun phrase is reached the model can be added to :

g----c

ate

Further additions to the model seem to depend on what the listener is going to have to do next. If it is not necessary to make a definite decision about scope then the model can halt with only the barest representation of the sentence. Perhaps a few mental footnotes may be made for future reference, but essentially the sentences remains ambiguous in the sense that the model does not disambiguate scope at this stage. On this model a sentence in which an existential was first quantifier would result in an identical representation.

If the reader is faced with a task that requires or forces scope disambiguation then the model must be fleshed out. This is necessary for reasoning tasks which require that a model or models be evaluated in order that a conclusion may be reached. However, in cases where a subsequent sentence biases the interpretation of a doubly quantified sentence in a particular direction completion of the model does not seem to be required. For example, for the sentence pair:

"All the girls ate a cake. The cake had been baked earlier that day."

the preferred interpretation is that the girls had shared a single cake, and requires the model :

```
g---->c
    //
g  /
  /
g

 ate
```

whereas for the sentence pair :

"All the girls ate a cake. The cakes had been decorated with different icings."

The preferred interpretation is that each of the girls ate a different cake, and requires the model :

```
g----c

g----c

g----c

 ate
```

However, Experiments 9 & 10 decribed in the thesis showed that the continuation sentences illustrating the converging reading were read faster regardless of which quantifier had occurred in the first sentence; this suggests that scope may not have been assigned at this stage. To contradict Fodor, who predicts extra processing time for the converging reading in universal first sentences if a "ditto" strategy has been used, it may be that the converging reading requires less alteration to the simple model "g----c",which acts as default scope for the sentence,than the diverging reading which requires that more paths are inserted into the model. Ultimately however it seems that a reading task of this nature does not need a well-specified model, and it seems that the task of processing subsequent information need not necessarily require anything more than a simple representation.

When people had to make a decision based on evaluating a diagram the experimental task required that they measure their internal model of the doubly quantified sentence with the diagram which appeared on screen. If a match occurred then response could be both fast and affirmative. If a match did not occur then the subject had two choices, either to reject the diagram or to modify their internal model of the sentence. Taken together, results from reading tasks and results from diagram evaluation tasks suggest that the default scope is modified only in the diagram evaluation tasks.

Different tasks seemingly require different strategies. It is plausible to suggest that a very simple representation is initially established as the default scope, and further that this default scope is only modified if absolutely necessary. This view also has the benefit of parsimony since a rich representation is costly and will be wasted if later tasks do not involve its use.

For the drawing tasks it was not imperative that people construct a fully worked out model of the sentence, (however only a small proportion of the diagrams were not classifiable as converging or diverging; this could be the influence of example diagrams shown to subjects before the experiment). The reading tasks also did not require that a complete model be constructed. Only the diagram evaluation tasks require a model in which scope is fully disambiguated in order that the experimental task is fulfilled.

In conclusion, it seems that people initially set up a default model for a doubly quantified sentence which does not fully disambiguate scope. Syntax (ie word order) affects the interpretive machinery in the first instance so that a rough model can be set up; perhaps a mental footnote marks the fact that the first quantifier is universal or existential. The effect of word order is later mediated by semantics (ie the characteristics of individual quantifiers) , context and general knowledge effects which combine to elicit the most plausible interpretation of the sentence being processed. Refining the mental model is an optional second stage which occurs only if made necessary by a subsequent task. These are tentative proposals and require further research if a substantial processing model of doubly quantified sentences is to be established.

Part 5. Suggestions for further research.

The current research has indicated a number of interesting avenues which could be explored to extend the findings of this thesis. One of the most interesting concerns the contrasting claims of Fodor and Johnson-Laird. Johnson-Laird et al's model of reasoning with quantified sentences postulates that the order in which the loops cycle is determined by scope decisions; the cycle begins with the quantifier assigned highest scope and descends through the quantifier assigned next highest scope and so on. This model assumes then that scope does not begin to be assigned until the whole sentence is read; then all the quantifiers in the sentence are organised in order of scope and processing of the sentence continues. Conversely Fodor suggests that schematic representations of doubly quantified sentences are begun as soon as the first quantifier is encountered, though these can be modified later if necessary. A useful way of investigating these contrasting claims would be to present sentence fragments and record reading times for these fragments. Longer reading times for later sentence fragments could reflect scope modifications in accordance with Fodor's predictions. Fast reading times for early parts of the sentence and a relatively long reading time for the final part of the sentence could reflect a scoping process in accordance with Johnson-Laird et al's prediction.

Fodor believes that it is psychologically parsimonious to delay scoping decisions until a sentence is available for comprehension in its entirety, because modifications to the initial representation can be avoided in this way. Fodor suggests that with spoken sentences reversed readings (ie those in which the final quantifier takes wide scope) can be signalled by the prosodic contour of the sentence. For example, the reversed reading for a sentence in which a singular quantifier is followed by a multiple quantifier corresponds to the diverging reading in which the multiple quantifier is given wide scope. Schematically this entails a multiplication of paths from the singular quantifier which has earlier been assigned a single path. Fodor believes that a prosodic break would signal this multiplication and encourage hearers to delay processing early parts of the sentence until the sentence is complete. She cites evidence from Cutler & Fodor (1979) which suggests that focussed phrases are interpreted first; this evidence would be compatible with the type of prosodic contour observed in doubly quantified sentences by Jackendoff (1972) and Lasnik (1975). Thus the most helpful prosodic contour for a hearer in this instance would be one that stresses the multiple quantifier and gives no precedence to the earlier quantifier. It would be useful to observe whether this is indeed the case by simulating prosodic breaks in an experimental situation and attempting to induce either the preferred or the reversed reading. A further research path would be to investigate whether any differences in scoping decisions occurred between written and spoken versions of the same doubly quantified sentences.

The last paragraph has discussed the question of when scope is assigned for a single sentence. However, it is also important to consider the question of when scope is assigned within a sequence of sentences. One way of accomplishing this would be to carry out an experiment which utilised three-sentence constructions. The first sentence would provide a preliminary context as in Experiments 8, 9 & 10. This could either be for the converging or the diverging reading.

The second sentence would be doubly quantified and compatible either with the converging or with the diverging reading. The final sentence would continue either the converging or the diverging interpretation. This last sentence could be replaced by a diagram evaluation task in a variation of the experimental design. Manipulation of the compatibility between sentences could be carried out so that in some cases the sentence sequences would be compatible and in some cases the sequences could be incompatible and require shifts in scoping decisions if scope had already been assigned. It is assumed that reading times for the sentence sequences would reflect the ease with which scope could be assigned and maintained, with relatively fast reading times for compatible sequences and relatively slow reading times for incompatible sequences. If longer reading times result at a particular point in the sequence then it is assumed that this would reflect a re-evaluation of scope assignment. Finally, a comparison could be made between the two types of task, the reading task in which a scoping decision is not formally required by the experimental design but in which the reading time for each portion of the sentence sequence is measured, and the diagram evaluation task in which people are required to give a definite decision regarding scope. It may be that only the diagram evaluation task results in complete scope assignment since this is necessary to fulfil the task; people can make do with a weakly specified model of scope for the reading task.

The thesis reported that support for Ioup's hierarchy of grammatical function was limited though not non-existent. The experiments described in the thesis examined only some of the grammatical functions of the universal. It would be useful to construct sentences which exploited the full range of grammatical functions which Ioup includes on her hierarchy, namely topic > deep and surface subject > deep or surface subject > indirect object > preposition object > direct object. On a related point although the experiments described in the thesis indicate strong support for the hierarchy of quantifiers which Ioup identifies it would be interesting to carry out research using sentences which include the quantified phrase "a few" which appears on Ioup's hierarchy but was not included in experiments reported in the thesis. This quantified phrase appears at the bottom of Ioup's hierarchy with the least inherent tendency towards highest scope.

Earlier in this section the problem of "multiple copies" was raised, ie that for some experiments it was not possible to distinguish between which of two candidate interpretations had been made. For example, for the sentence "Susan gave a recipe to some friends" it was not possible to tell from people's responses whether they interpreted the sentences as meaning that Susan gave different recipes to the friends or multiple copies of the same recipe to the friends. This problem would probably best be settled by asking people for a precise interpretation once they had completed the experimental task.

Finally, research cited earlier in the thesis suggests that pragmatics affect scoping decisions. One way of testing this hypothesis is to carry out an experiment which includes sentences in which plausibly there can only be one entity, (eg a king as in "All the children saw a King") sentences where there may be more than one entity (eg a book as in "All the children read a book") and sentences where there must be more than one entity (eg a biscuit as in "All the children ate a biscuit"). In sentences where there can only be one entity the converging reading should be preferred. In sentences where plausibly there must be more than one entity the diverging reading should be preferred. In the somewhat vaguer case where more than one entity may exist the number of readings of a particular type should give some indication of the interpretation people prefer. This strategy is one way of investigating the effect of pragmatic factors.

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APPENDIX 1(a).
Materials for Experiment 1.

PRACTICE SENTENCES.
A clown annoys all ringmasters.
All boyfriends are charmed by a girlfriend.
A duke scorns every princess.
Every porpoise is outswum by a dolphin.
Some liar cheats all conmen.
All cheetahs are outrun by some panther.
Some clown annoys every ringmaster.
Every boyfriend is charmed by some girlfriend.
Some dukes scorn all princesses.
All porpoises are outswum by some dolphins.
Some liars cheat every conman.
Every cheetah is outrun by some panthers.

TEST SENTENCES.

A president defeats all senators.
All teachers are admired by a pupil.
A doctor sees every patient.
Every man is attracted by a woman.
Some king flatters all queens.
All warders are feared by some prisoner.
Some lion scares every tiger.
Every scholar is interested by some philosopher.
Some boys befriend all girls.
All playmates are envied by some children.
Some voters respect every MP.
Every editor is disliked by some journalists.

APPENDIX 1(b).

Overall results for Experiment 1.

TABLE 1 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH CONDITION.

Sentence type	UNIVERSAL 1ST		UNIVERSAL 2ND		Means	
Reading type	CON	DIV	CON	DIV	CON	DIV
Condition						
a.......all	.75	.25	.92	.00	.83	.12
a.....every	.50	.50	.66	.33	.58	.41
some....all	.50	.50	.66	.25	.58	.37
some..every	.33	.66	.42	.58	.37	.62
some (pl).....all	.50	.50	.66	.25	.58	.37
some (pl)...every	.25	.58	.75	.25	.50	.41
means	.47	.49	.68	.28		

APPENDIX 2(¬)
Materials fo. Experiment 2.

PRACTICE SENTENCES.
A clown annoys all ringmasters.
All boyfriends are charmed by a girlfriend.
A duke scorns every princess.
Every porpoise is outswum by a dolphin.
Some liar cheats all conmen.
All cheetahs are outrun by some panther.
Some clown annoys every ringmaster.
Every boyfriend is charmed by some girlfriend.
Some dukes scorn all princesses.
All porpoises are outswum by some dolphins.
Some liars cheat every conman.
Every cheetah is outrun by some panthers.

TEST SENTENCES.

A witch tricks all sorcerers.
All teachers are admired by a pupil.
A doctor sees every patient.
Every man is attracted by a woman.
Some king flatters all queens.
All warders are feared by some prisoner.
Some lion scares every tiger.
Every scholar is interested by some philosopher.
Some boys befriend all girls.
All playmates are envied by some children.
Some voters respect every MP.
Every editor is disliked by some journalists.
A policeman hates all criminals.
All gamekeepers are outwitted by a poacher.
A boxer threatens every wrestler.
Every captain is impressed by a sailor.
Some sparrow chases all blackbirds.
All conductors are pleased by some musician.
Some soldier provokes every sargeant.
Every croupier is deceived by some gambler.
Some chimps pursue all baboons.
All actors are entertained by some singers.
Some secretaries help every clerk.
Every mule is kicked by some horses.

APPENDIX 2(b).

Overall results for Experiment 2.

TABLE 2.1 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Reading Type	CON	DIV	CON	DIV	CON	DIV
Condition						
a........all	1.42	0.58	1.75	0.25	1.58	0.41
a......every	1.00	1.00	1.58	0.42	1.29	0.71
some.....all	1.00	1.00	1.67	0.33	1.33	0.66
some...every	0.58	1.42	1.25	0.75	0.91	1.08
some(pl).....all	0.92	1.00	1.25	0.75	1.08	0.87
some(pl)...every	0.75	1.17	1.42	0.25	1.08	0.83
MEANS	0.94	1.03	1.49	0.50		

TABLE 2.2 MEAN RESPONSE TIMES (READING AND DRAWING TIMES, MSECS) FOR CONVERGING AND DIVERGING READINGS. (figures in brackets denote the mumber of scores available from which the mean was calculated; maximum is 24).

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Reading Type	CON	DIV	CON	DIV	CON	DIV
Condition						
a.......all	25213(17)	36799(7)	25567(21)	38164(3)	25390	37481
a.....every	25018(12)	27450(12)	22588(19)	29619(5)	23803	28534
some....all	24127(12)	24862(12)	21769(20)	31185(4)	22948	28023
some..every	20788(16)	27868(8)	23948(15)	19661(9)	22368	23764
some(pl)....all	28166(11)	28438(12)	29174(15)	19560(9)	28670	23999
some(pl)..every	33538(9)	31822(14)	28575(17)	29738(6)	31056	30780
Means	26142	29540	25270	27988		

APPENDIX 2(c)
Experiment 2 analyses.

Subject data
Diagram Choice.

SOURCE	DF	SS	MS	F	PROB
SUBJ	11	0.2813			
Order	1	0.0104	0.0104	0.3143	0.59166
EW1B	11	0.3646	0.0331		
Universal	1	0.0104	0.0104	0.3143	0.59166
EW2B	11	0.3646	0.0331		
Diagram	1	46.7604	46.7604	4.2469	0.06142
EW3B	11	121.1146	11.0104		
Order vs Universal	1	0.0104	0.0104	0.3143	0.59166
EW12B	11	0.3646	0.0331		
Order vs diagram	1	58.5938	58.5938	13.6319	0.00378
EW13B	11	47.2812	4.2983		
Universal vs diagram	1	12.7604	12.7604	4.2388	0.06164
EW23B	11	33.1146	3.0104		
Order vs universal vs diagram		3.0104	3.0104	2.2278	0.16116
EW123B	11	14.8646	1.3513		
W	84	338.6250			

TSQ/N= 846.0938 N= 96 SST= 338.9063

APPENDIX 2(d).
Experiment 2 analyses.

Subject data.
Response Time (reading and drawing time).

SOURCE	DF	SS	MS	F	PROB
SUBJ	11	253348496.1250			
Converging vs Diverging	1	56105126.0417	56105126.0417	2.5161	0.13830
EW1B	11	245282696.4583	22298426.9508		
W	12	301387822.5000			

TSQ/N= 17801721990.3750 N= 24 SST= 554736318.6250

Subject data.
Response times (ie reading and drawing time)

SOURCE	DF	SS	MS	F	PROB
SUBJ	5	214395089.8750			
Universal 1st vs Universal 2nd	1	8810028.3750	8810028.3750	1.4614	0.28078
EW1B	5	30143377.8750	6028675.5750		
Converging vs Diverging	1	56105126.0417	56105126.0417	1.7307	0.24485
EW2B	5	162091944.2083	32418388.8417		
Order vs Diagram.	1	694620.3750	694620.3750	0.0421	0.83875
EW12B	5	82496131.8750	16499226.3750		
W	18	340341228.7500			

TSQ/N= 17801721990.3750 N= 24 SST= 554736318.6250

APPENDIX 3(a).
Materials for Experiment 3.

TEST SENTENCES.

A witch tricks all sorcerers.
All pupils admire a teacher.
A doctor sees every patient.
Every woman attracts a man.
Some king flatters all queens.
All prisoners fear some warder.
Some lion scares every tiger.
Every philosopher interests some scholar.
Some boys befriend all girls.
All children envy some playmates.
Some voters respect every MP.
Every journalist dislikes some editors.
A policeman hates all criminals.
All poachers outwit a gamekeeper.
A boxer threatens every wrestler.
Every sailor impresses a captain.
Some sparrow chases all blackbirds.
All musicians please some conductor.
Some soldier provokes every sargeant.
Every gambler deceives some croupier.
Some chimps pursue all baboons.
All singers entertain some actors.
Some secretaries help every clerk.
Every horse kicks some mules.

APPENDIX 3(b).

Overall results for Experiment 3.

TABLE 3.1 MEAN NUMBER OF CONVERGING AND DIVERGING DIAGRAMS IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Reading Type	CON	DIV	CON	DIV	CON	DIV
Condition						
a.......all	1.16	0.83	1.67	0.33	1.41	0.58
a.....every	0.75	1.25	1.50	0.50	1.12	0.87
some....all	1.16	0.83	1.66	0.33	1.41	0.58
some..every	0.66	1.33	1.33	0.66	0.99	0.99
some(pl)....all	0.75	1.25	1.83	0.08	1.29	0.66
some(pl)..every	0.42	1.50	1.92	0.08	1.17	0.79
MEANS	0.82	1.16	1.65	0.33		

TABLE 3.2 MEAN RESPONSE TIME (READING AND DRAWING TIMES) (MSECS) IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Reading Type	CON	DIV	CON	DIV	CON	DIV
Condition						
a.......all	19278	29106	23621	40155	21449	34630
a.....every	22516	19770	25823	28173	24169	23971
some....all	23332	22658	20571	24703	21951	23680
some..every	21901	23088	23240	23763	22570	23425
some(pl)...all	24293	26219	24837	21663	24565	23941
some(pl)..every	23750	29199	22343	28516	23046	28857
Means	22512	25007	23406	27829		

APPENDIX 3(c)
Experiment 3 analyses

Subject data.
Diagram choice.

SOURCE	DF	SS	MS	F	PROB
SUBJ	11	0.2083			
Order	1	0.0000	0.0000	0.0000	1.00000
EW1B	11	0.2500	0.0227		
Universal	1	0.0000	0.0000	0.0000	1.00000
EW2B	11	0.2500	0.0227		
Diagram	1	51.0417	51.0417	2.9991	0.10845
EW3B	11	187.2083	17.0189		
Order vs universal	1	0.0417	0.0417	2.2000	0.16360
EW12B	11	0.2083	0.0189		
Order vs diagram	1	150.0000	150.0000	48.1752	0.00009
EW13B	11	34.2500	3.1136		
Universal vs diagram	1	16.6667	16.6667	12.5714	0.00475
EW23B	11	14.5833	1.3258		
Order vs universal vs diagram	1	3.3750	3.3750	2.3386	0.15184
EW123B	11	15.8750	1.4432		
W	84	473.7500			

TSQ/N= 852.0417 N= 96 SST= 473.9583

APPENDIX 3(d)
Experiment 3 analyses.

Subject data
Diagram choice.

SOURCE	DF	SS	MS	F	PROB
SUBJ	11	0.0764			
Order	1	0.0069	0.0069	1.0000	0.34059
EW1B	11	0.0764	0.0069		
Existential	2	0.0139	0.0069	1.0000	0.38582
EW2B	22	0.1528	0.0069		
Diagram	1	41.1736	41.1736	3.4774	0.08642
EW3B	11	130.2431	11.8403		
Order vs existential	2	0.0139	0.0069	1.0000	0.61419
EW12B	22	0.1528	0.0069		
Order vs diagram	1	88.6736	88.6736	48.5849	0.00009
EW13B	11	20.0764	1.8251		
Existential vs diag	2	0.5139	0.2569	0.1195	0.88764
EW23B	22	47.3194	2.1509		
Order vs existential vs diagram	2	11.8472	5.9236	5.7529	0.00979
EW123B	22	22.6528	1.0297		
W	132	362.9167			

TSQ/N= 572.0069 N= 144 SST= 362.9931

APPENDIX 3(e).

Experiment 3 analyses.

Subject data, response time (reading and drawing time).

SOURCE	DF	SS	MS	F	PROB
SUBJ	11	178826174.5000			
Converging vs Diverging.	1	71788086.0000	71788086.000	4.6418	0.05207
EW1B	11	170120532.0000	15465502.9091		
W	12	241908618.0000			

TSQ/N= 14628232513.5000 N=24 SST=420734792.5000

Subject data, response time (reading and drawing time)

SOURCE	DF	SS	MS	F	PROB
SUBJ	5	79058459.5000			
Universal 1st vs Universal 2nd.	1	20716700.1667	20716700.1667	1.3103	0.30466
EW1B	5	79051014.8333	15810202.9667		
Converging vs Diverging.	1	71788086.0000	71788086.0000	2.5663	0.16880
EW2B	5	139867442.0000	27973488.4000		
Order vs Diagram.	1	5575776.0000	5575776.0000	1.1297	0.33772
EW12B	5	24677314.0000	4935462.8000		
W	18	341676333.0000			

TSQ/N= 14628232513.5000 N= 24 SST= 420734792.5000

Subject data, response time for converging interpretations only.

SOURCE	DF	SS	MS	F	PROB
SUBJ		21104103821.7222			
Quantifier.	11	133468793.5556	12133526.6869	0.5072	0.87810
EW1B	22	526283530.2778	23921978.6490		
W	33	659752323.8333			

TSQ/N= 12679060268.4444 N= 36 SST=1763856145.5556

APPENDIX 4(a).
Materials for Experiment 4.

List A.

A playwright inspires all directors.
A pupil admires all teachers.
A doctor sees all patients.
A woman attracts all men.
A king flatters all queens.
All prisoners fear a warder.
All lions scare a tiger.
All philosophers interest a scholar.
All boys befriend a girl.
All children envy a playmate.
Every voter respects an MP.
Every journalist dislikes an editor.
Every policeman hates a criminal.
Every poacher outwits a gamekeeper.
Every boxer threatens a wrestler.
A sailor impresses every captain.
A sparrow chases every blackbird.
A musician pleases every conductor.
A soldier provokes every corporal.
A gambler deceives every croupier.
Some chimp pursues all baboons.
Some singer entertains all actors.
Some secretary helps all clerks.
Some horse kicks all mules.
Some duke scorns all princesses.
All clowns annoy some ringmaster.
All liars cheat some conman.
All cheetahs outrun some panther.
All ducks peck some cockerel.
All porpoises outswim some dolphin.
Every lawyer persuades some judge.
Every girl charms some boy.
Every dog chases some fox.
Every kitten bites some puppy.
Every nurse offends some patient.
Some driver upsets every traffic warden.
Some farmer opposes every developer.
Some student amuses every lecturer.
Some hawk attacks every eagle.
Some bully fights every schoolboy.

APPENDIX 4(a) continued.
List B.

All playwrights inspire a director.
All pupils admire a teacher.
All doctors see a patient.
All women attract a man.
All kings flatter a queen.
A prisoner fears all warders.
A lion scares all tigers.
A philosopher interests all scholars.
A boy befriends all girls.
A child envies all playmates.
A voter respects every MP.
A journalist dislikes every editor.
A policeman hates every criminal.
A poacher outwits every gamekeeper.
A boxer threatens every wrestler.
Every sailor impresses a captain.
Every sparrow chases a blackbird.
Every musician pleases a conductor.
Every soldier provokes a corporal.
Every gambler deceives a croupier.
All chimps pursue some baboon.
All singers entertain some actor.
All secretaries help some clerk.
All horses kick some mule.
All dukes scorn some princess.
Some clown annoys all ringmasters.
Some liar cheats all conmen.
Some cheetah ouruns all panthers.
Some duck pecks all cockerels.
Some porpoise outswims all dolphins.
Some lawyer persuades every judge.
Some girl charms every boy.
Some dog chases every fox.
Some kitten bites every puppy.
Some nurse offends every patient.
Every driver upsets some traffic warden.
Every farmer opposes some developer.
Every student amuses some lecturer.
Every hawk attacks some eagle.
Every bully fights some schoolboy.

APPENDIX 4(b).

Overall results tables for Experiment 4.

TABLE 4.1 MEAN READING TIMES (MSECS) FOR FIRST SENTENCE IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
Condition						
a.......all	2327	2811	2033	2403	2180	2607
a.....every	2290	1907	2130	2064	2210	1985
some....all	2168	2220	1894	2150	2031	2185
some..every	1305	1617	1480	2005	1392	1811
Means	2022	2139	1884	2155		

TABLE 4.2 MEAN EVALUATION TIME FOR DIAGRAMS IN EACH CONDITION (MSECS).

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
Condition						
a......all	1683	1376	2145	1237	1914	1306
a....every	2483	1946	1713	1947	2098	1946
some...all	1711	1641	1529	958	1620	1299
some.every	2404	1380	2118	2047	2261	1713
Means	2070	1586	1876	1547		

TABLE 4.3. MEAN SCORES FOR CONVERGING AND DIVERGING DIAGRAMS IN EACH CONDITION. (scores out of 5, CONVERGING=1, DIVERGING=0).

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Condition			
a......all	2.5	3.9	3.2
a....every	4.1	2.2	3.1
some...all	2.2	3.7	2.4
some.every	3.5	2.0	2.7
MEANS	3.1	2.9	

APPENDIX 4(c).

Experiment 4 analyses.

Subject data, response to diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	5	19.1875			
Universal	1	0.5208	0.5208	0.6757	0.54749
EW1B	5	3.8542	0.7708		
Existential	1	1.6875	1.6875	1.0305	0.35841
EW2B	5	8.1875	1.6375		
Order	1	0.5208	0.5208	3.0488	0.13990
EW3B	5	0.8542	0.1708		
Universal vs exist	1	0.0208	0.0208	0.0270	0.86972
EW12B	5	3.8542	0.7708		
Universal vs order	1	3.5208	3.5208	1.4851	0.27729
EW13B	5	11.8542	2.3708		
Existential vs order	1	0.1875	0.1875	0.2542	0.63786
EW23B	5	3.6875	0.7375		
Universal vs exist vs order.	1	0.5208	0.5208	1.9231	0.22332
EW123B	5	1.3542	0.2708		
W	42	40.6250			

TSQ/N= 567.1875 N= 48 SST= 59.8125

APPENDIX 4(d).

Experiment 4 analyses.

Sentence data,response to diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	7	3.7500			
Universal	1	0.2500	0.2500	0.1750	0.68904
EW1B	7	10.0000	1.4286		
Existential	1	1.0000	1.0000	3.1111	0.11905
EW2B	7	2.2500	0.3214		
Order	1	2.2500	2.2500	1.5000	0.25977
EW3B	7	10.5000	1.5000		
Universal vs exist	1	0.2500	0.2500	3.5000	0.10151
EW12B	7	0.5000	0.0714		
Universal vs order	1	0.2500	0.2500	0.0449	0.83184
EW13B	7	39.0000	5.5714		
Existential vs order	1	2.2500	2.2500	2.6250	0.14723
EW23B	7	6.0000	0.8571		
Universal vs exist vs order.	1	0.2500	0.2500	0.2692	0.62357
EW123B	7	6.5000	0.9286		
W	56	81.2500			

TSQ/N= 625.0000 N= 64 SST= 85.0000

APPENDIX 4(e).

Experiment 4 analyses.

Sentence data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	6	1361377.8571			
A 1st vs All 1st	1	531880.4575	531880.4575	6.7465	0.03985
EW1B	6	473024.5400	78837.4233		
Converging vs Diverging.	1	7679.2032	7679.2032	0.0109	0.91674
EW2B	6	4211408.2543	701901.3757		
Order vs diagram.	1	331165.5004	331165.5004	0.9774	0.63703
EW12B	6	2032838.2571	338806.3762		
W	21	7587996.2125			

TSQ/N= 132482296.1604 N= 28 SST= 8949374.0696

Subject data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	12645822.8970			
A 1st vs All 1st	1	615162.8880	615162.8880	4.2818	0.10677
EW1B	4	574677.7370	143669.4343		
Converging vs Diverging.	1	911901.2180	911901.2180	1.3967	0.30317
EW2B	4	2611659.8670	652914.9668		
Order vs diagram.	1	16290.6320	16290.6320	0.0255	0.87480
EW12B	4	2554908.0430	638727.0108		
W	15	7284600.3850			

TSQ/N= 114612271.5380 N= 20 SST= 19930423.2820

APPENDIX 4(f).

Experiment 4 analyses.

Sentence data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	6	827299.6021			
A 1st vs Every 1st	1	9542.3432	9542.3432	0.0182	0.89205
EW1B	6	3141796.5393	523632.7565		
Converging vs Diverging.	1	2766.1032	2766.1032	0.0021	0.96431
EW2B	6	8041865.1393	1340310.8565		
Order vs diagram.	1	945504.0032	945504.0032	3.2595	0.11928
EW12B	6	1740453.0393	290075.5065		
W	21	13881927.1675			

TSQ/N= 156061628.4004 N= 28 SST= 14709226.7696

Subject data, reading times.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	15601583.3730			
A 1st vs Every 1st	1	12.1680	12.1680	0.0004	0.98201
EW1B	4	108676.4970	27169.1243		
Converging vs Diverging	1	252810.0980	252810.0980	1.6039	0.27406
EW2B	4	630480.1570	157620.0393		
Order vs Diagram	1	126405.0000	126405.0000	0.2710	0.63189
EW12B	4	1865538.7650	466384.6913		
W	15	2983922.6850			

TSQ/N= 88014457.6820 N= 20 SST= 18585506.0580

APPENDIX 4(g).

Experiment 4 analyses.

Sentence data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	8	54629759.0350			
Some 1st vs All 1st	1	14790.6136	14790.6136	0.0408	0.83858
EW1B	8	2899325.4239	362415.6780		
Converging vs Diverging.	1	59951.5225	59951.5225	0.1636	0.69702
EW2B	8	2930978.4150	366372.3019		
Order vs diagram.	1	2226710.5803	2226710.5803	1.1665	0.31240
EW12B	8	15270572.9572	1908821.6197		
W	27	23402329.5125			

TSQ/N= 154491227.3025 N= 36 SST= 78032088.5475

Subject data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	12290967.3450			
Some 1st vs All 1st	1	148298.6420	148298.6420	0.2344	0.65453
EW1B	4	2531049.4530	632762.3633		
Converging vs Diverging.	1	117841.9520	117841.9520	0.3738	0.57697
EW2B	4	1261006.8930	315251.7233		
Order vs diagram.	1	51592.4820	51592.4820	0.4149	0.55775
EW12B	4	497355.9130	124338.9783		
W	15	4607145.3350			

TSQ/N= 88890144.8000 N= 20 SST= 16898112.6800

APPENDIX 4(h).

Experiment 4 analyses.

Sentence data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	8	19619169.5239			
Some 1st vs Every 1st	1	2859875.5803	2859875.5803	2.3010	0.16569
EW1B	8	9943107.3672	1242888.4209		
Converging vs Diverging.	1	3827174.9003	3827174.9003	4.0842	0.07582
EW2B	8	7496480.6072	937060.0759		
Order vs Diagram.	1	4110148.0225	4110148.0225	2.3356	0.16287
EW12B	8	14078265.3550	1759783.1694		
W	27	42315051.8325			

TSQ/N= 234782581.5136 N= 36 SST= 61934221.3564

Subject data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	40529674.8950			
Some 1st vs Every 1st.	1	395198.4980	395198.4980	0.8410	0.58624
EW1B	4	1879708.4870	469927.1218		
Converging vs Diverging.	1	876967.2000	876967.2000	3.6928	0.12637
EW2B	4	949919.8950	237479.9738		
Order vs diagram.	1	56668.6580	56668.6580	0.0966	0.76637
EW12B	4	2346721.4270	586680.3567		
W	15	6505184.1650			

TSQ/N= 51328080.0000 N= 20 SST= 47034859.0600

APPENDIX 4(i).

Experiment 4 analyses.

Subject data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	12617360.3570			
A 1st vs All 1st	1	739931.9805	739931.9805	0.5833	0.50875
EW1B	4	5074293.3870	1268573.3468		
Converging vs Diverging.	1	115322.4845	115322.4845	0.2259	0.66004
EW2B	4	2041852.1330	510463.0333		
Order vs Diagram.	1	743552.4845	743552.4845	1.8443	0.24565
EW12B	4	1612649.9230	403162.4807		
W	15	10327602.3925			

TSQ/N= 81810529.5005 N= 20 SST= 22944962.7495

Sentence data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	6	3063500.8086			
A 1st vs All 1st	1	425631.6014	425631.6014	1.3657	0.28700
EW1B	6	1869966.2886	311661.0481		
Converging vs Diverging.	1	229073.6700	229073.6700	0.7552	0.57802
EW2B	6	1819984.4800	303330.7467		
Order vs Diagram.	1	2021376.3657	2021376.3657	3.0612	0.12900
EW12B	6	3961920.8743	660320.1457		
W	21	10327953.2800			

TSQ/N= 109223820.0914 N= 28 SST= 13391454.0886

APPENDIX 4(j).

Experiment 4 analyses.

Subject data , evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	12617360.3570			
A 1st vs Every 1st.	1	739931.9805	739931.9805	0.5833	0.50875
EW1B	4	5074293.3870	1268573.3468		
Converging vs Diverging.	1	115322.4845	115322.4845	0.2259	0.66004
EW2B	4	2041852.1330	510463.0333		
Order vs Diagram.	1	743552.4845	743552.4845	1.8443	0.24565
EW12B	4	1612649.9230	403162.4807		
W	15	10327602.3925			

TSQ/N= 81810529.5005 N= 20 SST= 22944962.7495

Sentence data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	6	7653087.5771			
A 1st vs Every 1st	1	862301.7032	862301.7032	1.1338	0.32909
EW1B	6	4563168.6243	760528.1040		
Converging vs Diverging.	1	374891.1432	374891.1432	0.8818	0.61332
EW2B	6	2550719.2443	425119.8740		
Order vs Diagram.	1	2831281.2032	2831281.2032	7.1706	0.03580
EW12B	6	2369073.5743	394845.5957		
W	21	13551435.4925			

TSQ/N= 118700114.6604 N= 28 SST= 21204523.0696

APPENDIX 4(k).

Experiment 4 analyses.

Subject data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	3228258.9880			
Some 1st vs All 1st	1	825804.8000	825804.8000	1.6840	0.26402
EW1B	4	1961518.5100	490379.6275		
Converging vs Diverging.	1	467262.4500	467262.4500	2.1484	0.21601
EW2B	4	869989.6500	217497.4125		
Order vs diagram.	1	657031.2500	657031.2500	0.7828	0.57066
EW12B	4	3357490.4200	839372.6050		
W	15	8139097.0800			

TSQ/N= 61070931.0720 N= 20 SST= 11367356.0680

Sentence data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	8	36974537.8050			
Some 1st vs All 1st	1	555670.8544	555670.8544	0.7678	0.58973
EW1B	8	5789652.7406	723706.5926		
Converging vs Diverging.	1	1526789.7344	1526789.7344	3.6549	0.09004
EW2B	8	3341943.8706	417742.9838		
Order vs Diagram.	1	2166293.3611	2166293.3611	1.8126	0.21363
EW12B	8	9561256.3439	1195157.0430		
W	27	22941606.9050			

TSQ/N= 105470846.0100 N= 36 SST= 59916144.7100

APPENDIX 4(1).

Experiment 4 analyses.

Subject data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	12601728.7600			
Some 1st vs Every 1st	1	564312.0125	564312.0125	5.1255	0.08592
EW1B	4	440399.2200	110099.8050		
Converging vs Diverging.	1	899092.0125	899092.0125	3.9572	0.11694
EW2B	4	908820.7200	227205.1800		
Order vs Diagram.	1	42182.1125	42182.1125	0.9907	0.62221
EW12B	4	170312.7600	42578.1900		
W	15	3025118.8375			

TSQ/N= 18431040.0125 N= 20 SST= 15626847.5975

Sentence data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	8	6648777.2800			
Some 1st vs Every 1st.	1	324102.4900	324102.4900	0.7203	0.57503
EW1B	8	3599474.4900	449934.3112		
Converging vs Diverging.	1	2695397.7878	2695397.7878	2.2804	0.16741
EW2B	8	9456009.6922	1182001.2115		
Order vs diagram.	1	2043470.2500	2043470.2500	2.4792	0.15183
EW12B	8	6594031.7400	824253.9675		
W	27	24712486.4500			

TSQ/N= 142179391.2100 N= 36 SST= 31361263.7300

APPENDIX 5(a).
Materials for Experiment 5.

List A.

Some dogs chase all foxes.
Some pupils admire all teachers.
Some kings flatter all queens.
Some journalists dislike all editors.
Some poachers outwit all gamekeepers.
All sailors impress some captains.
All soldiers provoke some corporals.
All sparrows chase some blackbirds.
All lions scare some tigers.
All children envy some playmates.
Every playwright inspires some directors.
Every doctor sees some patients.
Every woman attracts some men.
Every prisoner fears some warders.
Every philosopher interests some scholars.
Some chimps pursue every baboon.
Some singers entertain every actor.
Some secretaries help every clerk.
Some liars cheat every conman.
Some nurses offend every patient.

List B.

All dogs chase some foxes.
All pupils admire some teachers.
All kings flatter some queens.
All journalists dislike some editors.
All poachers outwit some gamekeepers.
Some sailors impress all captains.
Some soldiers provoke all corporals.
Some sparrows chase all blackbirds.
Some lions scare all tigers.
Some children envy all playmates.
Some playwrights inspire every director.
Some doctors see every patient.
Some women attract every man.
Some prisoners fear every warder.
Some philosophers interest every scholar.
Every chimp pursues some baboons.
Every singer entertains some actors.
Every secretary helps some clerks.
Every liar cheats some conmen.
Every nurse offends some patient.

APPENDIX 5(b).

Overall results tables for Experiment 5.

TABLE 5.1 MEAN NUMBER OF CONVERGING AND DIVERGING READINGS IN EACH CONDITION (scores out of 5. Converging=1,diverging=0).

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
some(pl)....all	2.1	2.9	4.4	0.6	3.2	1.7
some(pl)..every	4.4	0.6	2.5	2.5	3.4	2.0
Means	3.2	1.7	3.4	1.5		

TABLE 5.2 MEAN READING TIME (MSECS) FOR DOUBLY QUANTIFIED SENTENCE IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
Condition						
some(pl).....all	3310	3338	3452	4332	3381	3835
some(pl)...every	2728	3486	2468	3496	2598	3491
Means	3019	3412	2960	3914		

TABLE 5.3 MEAN EVALUATION TIME (MSECS) IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
Condition						
some(pl).....all	5079	4503	4850	4879	4964	4691
some(pl)...every	4908	3943	3682	3276	4295	3609
Means	4993	4223	4266	4077		

APPENDIX 5(c).

Experiment 5 analyses.

Subject data, number of converging and diverging readings.

SOURCE	DF	SS	MS	F	PROB
SUBJ	9	19.6000			
Order.	1	0.4000	0.4000	1.7143	0.22143
EW1B	9	2.1000	0.2333		
Universal.	1	0.4000	0.4000	0.8780	0.62401
EW2B	9	4.1000	0.4556		
Universal vs order.	1	44.1000	44.1000	27.5625	0.00079
EW12B	9	14.4000	1.6000		
W	30	65.5000			

TSQ/N= 448.9000 N= 40 SST= 85.1000

Sentence data, number of converging and diverging diagrams.

SOURCE	DF	SS	MS	F	PROB
SUBJ	8	9.3889			
Order.	1	1.0000	1.0000	1.4545	0.26173
EW1B	8	5.5000	0.6875		
Universal.	1	11.1111	11.1111	20.2532	0.00235
EW2B	8	4.3889	0.5486		
Universal vs order	1	1.0000	1.0000	0.2192	0.65499
EW12B	8	36.5000	4.5625		
W	27	59.5000			

TSQ/N= 427.1111 N= 36 SST= 68.8889

APPENDIX 5(d).

Experiment 5 analyses.

Subject data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	61723137.0730			
Some 1st vs All 1st	1	1029445.3125	1029445.3125	0.5597	0.50043
EW1B	4	7356852.1950	1839213.0488		
Converging vs Diverging.	1	1612836.0125	1612836.0125	2.7972	0.16901
EW2B	4	2306344.5350	576586.1337		
Order vs diagram.	1	908956.8845	908956.8845	0.1774	0.69422
EW12B	4	20490472.4530	5122618.1133		
W	15	33704907.3925			

TSQ/N= 260351115.2045 N= 20 SST= 95428044.4655

Sentence data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	7153785.8170			
Some 1st vs All 1st	1	758940.8000	758940.8000	0.3488	0.58933
EW1B	4	8702694.8550	2175673.7138		
Converging vs Diverging.	1	23957.0420	23957.0420	0.0119	0.91501
EW2B	4	8079823.9130	2019955.9782		
Order vs Diagram.	1	371444.7680	371444.7680	0.3078	0.61096
EW12B	4	4827468.6470	1206867.1618		
W	15	22764330.0250			

TSQ/N= 185509932.4980 N= 20 SST= 29918115.8420

APPENDIX 5(e).

Experiment 5 analyses.

Subject data, reading times.

SOURCE	DF	SS	MS	F	PROB
SUBJ	3	23984321.3919			
Some 1st vs Every 1st	1	3187028.3006	3187028.3006	1.5203	0.30580
EW1B	3	6289036.7469	2096345.5823		
Converging vs Diverging.	1	62063.2656	62063.2656	0.0408	0.84562
EW2B	3	4566306.3319	1522102.1106		
Order vs diagram.	1	72778.5506	72778.5506	0.0313	0.86417
EW12B	3	6979634.5069	2326544.8356		
W	12	21156847.7025			

TSQ/N= 148306728.5156 N= 16 SST= 45141169.0944

Sentence data, reading time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	73559564.7080			
Some 1st vs Every 1st.	1	1923426.2645	1923426.2645	0.6074	0.51702
EW1B	4	12666537.0080	3166634.2520		
Converging vs Diverging.	1	2147155.9805	2147155.9805	0.4699	0.53408
EW2B	4	18279034.2820	4569758.5705		
Order vs Diagram.	1	557012.0645	557012.0645	0.2998	0.61539
EW12B	4	7432567.9580	1858141.9895		
W	15	43005733.5575			

TSQ/N= 108390283.2045 N= 20 SST= 116565298.2655

APPENDIX 5(f).

Experiment 5 analyses.

Subject data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	21853451.2300			
Some 1st vs All 1st	1	27143.7120	27143.7120	0.0315	0.86114
EW1B	4	3445345.4680	861336.3670		
Converging vs Diverging.	1	372699.6020	372699.6020	0.1352	0.72878
EW2B	4	11030683.6780	2757670.9195		
Order vs diagram.	1	456926.4500	456926.4500	0.1242	0.73868
EW12B	4	14710491.9800	3677622.9950		
W	15	30043290.8900			

TSQ/N= 466191680.0000 N= 20 SST= 51896742.1200

Sentence data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	4639997.6730			
Some 1st vs All 1st	1	1550855.1245	1550855.1245	0.9234	0.60671
EW1B	4	6718225.2430	1679556.3107		
Converging vs Diverging.	1	6510431.9405	6510431.9405	16.7701	0.01601
EW2B	4	1552866.1770	388216.5442		
Order vs Diagram.	1	2676412.2845	2676412.2845	0.7257	0.55437
EW12B	4	14752656.8830	3688164.2208		
W	15	33761447.6525			

TSQ/N= 318268747.9445 N= 20 SST= 38401445.3255

APPENDIX 5(g).

Experiment 5 analyses.

Subject data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	84682658.3250			
Some 1st vs Every 1st.	1	4482245.8805	4482245.8805	0.7003	0.54677
EW1B	4	25603430.3270	6400857.5818		
Converging vs Diverging.	1	2351128.1645	2351128.1645	0.6203	0.52133
EW2B	4	15162435.8530	3790608.9633		
Order vs Diagram.	1	390908.7605	390908.7605	0.6884	0.54315
EW12B	4	2271359.9670	567839.9917		
W	15	50261508.9525			

TSQ/N= 312433267.6125 N= 20 SST= 134944167.2775

Sentence data, evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	4	98062476.7970			
Some 1st vs Every 1st	1	2410956.8000	2410956.8000	0.5013	0.52147
EW1B	4	19239419.2950	4809854.8238		
Converging vs Diverging.	1	2461493.4480	2461493.4480	1.4210	0.29950
EW2B	4	6929067.4470	1732266.8618		
Order vs Diagram.	1	161820.0500	161820.0500	0.1660	0.70307
EW12B	4	3899993.4450	974998.3612		
W	15	35102750.4850			

TSQ/N= 144284399.2980 N= 20 SST= 133165227.2820

APPENDIX 6(a).
Materials for Experiment 6.

A playwright inspires all directors.
A footballer beats all goalkeepers.
A pupil admires all teachers.
A pianist teaches all violinists.
A patient is seen by all doctors.
A postman is chased by all dogs.
A man is attracted by all women.
A dentist is hated by all clients.
All prisoners fear a warder.
All marksmen hit a sniper.
All lions scare a tiger.
All curates fear a vicar.
All scholars are interested by a philosopher.
All telephonists are confused by a caller.
All girls are befriended by a boy.
All busdrivers are insulted by a motorist.
Some chimp pursues all baboons.
Some dog chases all foxes.
Some singer entertains all actors.
Some recruit admires all sargeants.
Some clerk is helped by all secretaries.
Some queen is flattered by all kings.
Some mule is kicked by all horses.
Some editor is disliked by all journalists.
All clowns annoy some ringmaster.
All sailors impress some captain.
All liars cheat some conman.
All sparrows chase some blackbird.
All panthers are outrun by some cheetah.
All companies are sued by some solicitor.
All dolphins are outswum by some porpoise.
All playmates are envied by some child.
A pilot impresses every general.
A farmer calls every vet.
A musician pleases every conductor.
A headmaster punishes every pupil.
A corporal is provoked by every soldier.
A chef is pitied by every waitress.
A croupier is deceived by every gambler.
A grocer is cheated by every confectioner.
Every voter respects an MP.
Every pickpocket imitates a robber.
Every policeman hates a criminal.
Every dustman envies an engineer.
Every gamekeeper is outwitted by a poacher.
Every baker is envied by a cook.
Every wrestler is threatened by a boxer.
Every writer is reviled by a critic.
Some driver upsets every traffic warden.
Some jockey scolds every trainer.
Some farmer opposes every developer.
Some swimmer defeats every opponent.
Some lecturer is amused by every student.
Some princess is scorned by every suitor.
Some eagle is attacked by every hawk.

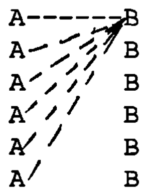
Some duck is pecked by every seagull.
Every lawyer persuades some judge.
Every nurse offends some patient.
Every girl charms some boy.
Every bully fights some schoolboy.
Every fox is chased by some dog.
Every builder is cheated by some customer.
Every kitten is bitten by some puppy.
Every cat is scratched by some kitten.

APPENDIX 6(b).

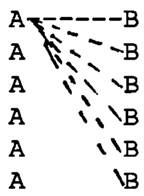
Diagram types used in Experiment 6.

```
A------B
A------B
A------B
A------B
A------B
A------B
```

parallel



converging right



converging left

APPENDIX 6(c).

Overall results tables for Experiment 6.

TABLE 6.1 MEAN NUMBER OF CONVERGING AND DIVERGING DIAGRAMS CHOSEN IN EACH CONDITION.(Scores out of 2).

Sentence Type	UNIVERSAL 1ST				UNIVERSAL 2ND					
Voice	Active		Passive		Active		Passive		Means	
Diagram Type	CON	DIV	CON	DIV	CON	DIV	CON	DIV	CON	DIV
Condition										
All........a	1.84	0.59	1.77	0.92	1.92	0.48	1.86	0.48	1.85	0.62
Every......a	1.62	0.80	1.59	0.94	1.66	0.58	1.81	0.59	1.67	0.73
All.....some	1.42	1.64	1.56	1.69	1.62	1.58	1.64	1.39	1.56	1.57
Every...some	1.19	1.55	1.37	1.50	1.25	1.47	1.52	1.39	1.33	1.48
Means	1.52	1.14	1.57	1.26	1.61	1.03	1.71	0.96		

TABLE 6.2 MEAN READING TIME (MSECS) FOR CONVERGING DIAGRAMS IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS
Voice	Active	Passive	Active	Passive	
Diagram Type	CON	CON	CON	CON	CON
Quantifiers					
All........a	1803	2077	2186	2220	2071
Every......a	2035	2209	2020	2363	2157
All.....some	2218	2372	2128	2591	2327
Every...some	1841	2654	1891	2258	2161
Means	1974	2328	2056	2358	

APPENDIX 6(c) continued.

TABLE 6.3 MEAN EVALUATION TIME (MSECS) FOR CONVERGING DIAGRAMS IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST		UNIVERSAL 2ND		MEANS
Voice	Active	Passive	Active	Passive	
Diagram Type	CON	CON	CON	CON	
Quantifiers					
All........a	1724	1833	1419	1639	1654
Every......a	1867	2075	1591	1941	1868
All.....some	2082	1918	1879	1628	1877
Every...some	1938	2111	1743	1837	1907
Means	1903	1984	1658	1761	

APPENDIX 6(d).

Experiment 6 analyses.

Subject data, number of YES responses.

SOURCE	DF	SS	MS	F	PROB
SUBJ	63	74.6250			
Order	1	1.1250	1.1250	3.3353	0.06907
EW1B	63	21.2500	0.3373		
Universal	1	5.0801	5.0801	9.2312	0.00376
EW2B	63	34.6699	0.5503		
Existential	1	37.1953	37.1953	53.1908	0.00000
EW3B	63	44.0547	0.6993		
Voice	1	1.3203	1.3203	3.9273	0.04900
EW4B	63	21.1797	0.3362		
Diagram	1	130.0078	130.0078	55.2974	0.00000
EW5B	63	148.1172	2.3511		
Order vs universal.	1	0.0488	0.0488	0.2398	0.63164
EW12B	63	12.8262	0.2036		
Order vs existential	1	0.7813	0.7813	1.9614	0.16279
EW13B	63	25.0938	0.3983		
Order vs voice.	1	0.6328	0.6328	2.3812	0.12393
EW14B	63	16.7422	0.2657		
Order vs diagram.	1	13.1328	13.1328	36.1814	0.00001
EW15B	63	22.8672	0.3630		
Universal vs exist.	1	2.1270	2.1270	6.9167	0.01040
EW23B	63	19.3730	0.3075		
Universal vs voice	1	0.3301	0.3301	1.4421	0.23238
EW24B	63	14.4199	0.2289		
Universal vs diag.	1	5.4863	5.4863	8.6111	0.00487
EW25B	63	40.1387	0.6371		
Existential vs voice	1	0.0313	0.0313	0.0773	0.77849
EW34B	63	25.4688	0.4043		
Existential vs diag.	1	173.4453	173.4453	173.6391	0.00000
EW35B	63	62.9297	0.9989		
Voice vs Diagram.	1	0.2813	0.2813	0.9403	0.66254
EW45B	63	18.8438	0.2991		
Order vs universal vs existential.	1	0.0020	0.0020	0.0084	0.92443
EW123B	63	14.6230	0.2321		

APPENDIX 6(d) continued.

Order vs universal vs voice.	1	1.2207	1.2207	4.8354	0.02967
EW124B	63	15.9043	0.2524		
Order vs universal vs diagram.	1	0.0488	0.0488	0.2471	0.62667
EW125B	63	12.4512	0.1976		
Order vs existential vs voice.	1	0.0078	0.0078	0.0301	0.85714
EW134B	63	16.3672	0.2598		
Order vs existential vs diagram.	1	0.5000	0.5000	1.3846	0.24212
EW135B	63	22.7500	0.3611		
Order vs voice vs diagram.	1	1.5313	1.5313	4.7713	0.03071
EW145B	63	20.2188	0.3209		
Universal vs exist vs voice.	1	0.0957	0.0957	0.2691	0.61197
EW234B	63	22.4043	0.3556		
Universal vs exist vs diagram.	1	0.7051	0.7051	1.9813	0.16066
EW235B	63	22.4199	0.3559		
Universal vs voice vs diagram.	1	1.0332	1.0332	3.6483	0.05750
EW245B	63	17.8418	0.2832		
Existential vs voice vs diagram.	1	3.7813	3.7813	16.9024	0.00029
EW345B	63	14.0938	0.2237		
Order vs univ. vs exist.vs voice.	1	0.0020	0.0020	0.0096	0.91933
EW1234B	63	12.8730	0.2043		
Order vs univ. vs exist vs diagram.	1	0.2363	0.2363	0.7171	0.59503
EW1235B	63	20.7637	0.3296		
Order vs univ. vs voice vs diagram.	1	0.0020	0.0020	0.0067	0.93303
EW1245B	63	18.4980	0.2936		
Order vs exist. vs voice vs diagram.	1	0.3828	0.3828	1.0000	0.32243
EW1345B	63	24.1172	0.3828		
Universal vs exist. vs voice vs diagram.	1	0.0488	0.0488	0.1592	0.69371
EW2345B	63	19.3262	0.3068		

APPENDIX 6(d) continued.

Order vs univ. vs exist vs voice vs diagram.	1	0.0020	0.0020	0.0072	0.93005
EW12345B	63	16.9980	0.2698		
W	1984	1200.2500			

TSQ/N= 3741.1250 N= 2048 SST= 1274.8750

APPENDIX 6(e).

Experiment 6 analyses.

Sentence data, number of YES responses.

SOURCE	DF	SS	MS	F	PROB
SUBJ	63	332.0000			
Universal	1	4.5000	4.5000	0.8795	0.64550
Existential	1	20.3203	20.3203	3.9716	0.04800
Uni. vs exist.	1	0.1953	0.1953	0.0382	0.83999
EB12	60	306.9844	5.1164		
Order	1	148.7813	148.7813	67.8447	0.00000
Order vs universal.	1	3.1250	3.1250	1.4250	0.23546
Order vs exist.	1	8.5078	8.5078	3.8796	0.05057
Order vs universal vs existential.	1	0.0078	0.0078	0.0036	0.95132
EW1B12	60	131.5781	2.1930		
Voice	1	5.2813	5.2813	2.9619	0.08665
Voice vs universal.	1	2.5313	2.5313	1.4196	0.23637
Voice vs exist.	1	1.3203	1.3203	0.7405	0.60273
Voice vs universal vs existential.	1	4.8828	4.8828	2.7384	0.09933
EW2B12	60	106.9844	1.7831		
Diagram	1	520.0313	520.0313	329.1446	0.00000
Diagram vs univer.	1	52.5313	52.5313	33.2487	0.00001
Diagram vs exist.	1	21.9453	21.9453	13.8899	0.00071
Diagram vs univer. vs existential.	1	0.1953	0.1953	0.1236	0.72655
EW3B12	60	94.7969	1.5799		
Order vs voice.	1	0.1250	0.1250	0.0715	0.78626
Order vs voice vsuniversal.	1	0.0313	0.0313	0.0179	0.88931
Order vs voice vs existential.	1	0.3828	0.3828	0.2188	0.64662
Order vs voice vs uni. vs exist.	1	0.0078	0.0078	0.0045	0.94540
EW12B12	60	104.9531	1.7492		
Order vs diagram.	1	693.7813	693.7813	418.5577	0.00000
Order vs diagram vs universal.	1	2.0000	2.0000	1.2066	0.27591
Order vs diagram vs existential	1	2.8203	2.8203	1.7015	0.19419
Order vs diagram vs uni. vs exist.	1	0.9453	0.9453	0.5703	0.54045
EW13B12	60	99.4531	1.6576		

APPENDIX 6(e) continued.

Voice vs diagram.	1	1.1250	1.1250	0.6709	0.57875
Voice vs diagram vs universal.	1	6.1250	6.1250	3.6527	0.05759
Voice vs diagram vs existential.	1	4.1328	4.1328	2.4647	0.11781
Voice vs diagram vs uni. vs exist.	1	0.0078	0.0078	0.0047	0.94421
EW23B12	60	100.6094	1.6768		
Order vs voice vs diagram.	1	15.1250	15.1250	12.3234	0.00120
Order vs voice vs diagram vs uni.	1	1.5313	1.5313	1.2476	0.26768
Order vs voice vs diagram vs exist.	1	0.1953	0.1953	0.1591	0.69380
Order vs voice vs diagram vs uni. vs existential.	1	0.0078	0.0078	0.0064	0.93454
EW123B12	60	73.6406	1.2273		
W	448	2209.5000			

TSQ/N= 14964.5000 N= 512 SST= 2541.5000

APPENDIX 6(f)

Experiment 6 analyses.

Subject data, reading time for doubly quantified sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	28	144101490.5129			
Order	1	360423.7586	360423.7586	0.7219	0.59269
EW1B	28	13979956.6164	499284.1649		
Universal	1	191323.4569	191323.4569	0.2729	0.61142
EW2B	28	19632911.6681	701175.4167		
Existential	1	1960660.0086	1960660.0086	3.5311	0.06750
EW3B	28	15547055.3664	555251.9774		
Voice	1	12448275.8621	12448275.8621	31.5798	0.00004
EW4B	28	11037189.0129	394185.3219		
Order vs universal	1	1346767.2500	1346767.2500	2.9318	0.09438
EW12B	28	12862447.3750	459373.1205		
Order vs existential	1	1418821.0431	1418821.0431	1.6210	0.21114
EW13B	28	24507781.8319	875277.9226		
Order vs voice	1	79354.7931	79354.7931	0.1208	0.73044
EW14B	28	18398579.0819	657092.1101		
Universal vs exist	1	1834566.7586	1834566.7586	3.5072	0.06839
EW23B	28	14646350.3664	523083.9417		
Universal vs voice	1	1072322.4914	1072322.4914	2.0704	0.15800
EW24B	28	14501832.1336	517922.5762		
Existential vs voice	1	1712178.0086	1712178.0086	7.0778	0.01228
EW34B	28	6773400.3664	241907.1559		
Order vs universal vs existential	1	13169.7931	13169.7931	0.0299	0.85824
EW123B	28	12349707.3319	441060.9761		
Order vs universal vs voice	1	216812.2845	216812.2845	0.4720	0.50441
EW124B	28	12860742.8405	459312.2443		
Order vs existential vs voice	1	8161.4569	8161.4569	0.0081	0.92638
EW134B	28	28298902.4181	1010675.0864		
Universal vs exist vs voice	1	227400.8276	227400.8276	0.4748	0.50319
EW234B	28	13411643.2974	478987.2606		
Order vs universal vs existential vs	1	2456331.0345	2456331.0345	6.2212	0.01784

voice			
EW1234B	28	11055317.0905	394832.7532
W	435	255210385.6250	

TSQ/N= 2203683751.8621 N= 464 SST= 399311876.1379

APPENDIX 6(g)

Experiment 6 analyses.

Sentence data, reading time for doubly quantified sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	55	16749429.3571			
Universal	1	11629.4464	11629.4464	0.0443	0.82858
Existential	1	1733248.2857	1733248.2857	6.5968	0.01260
Universal vs exist	1	1341992.1607	1341992.1607	5.1077	0.02638
EB12	52	13662559.4643	262741.5282		
Order	1	1538823.0179	1538823.0179	6.3769	0.01399
Order vs universal	1	32737.7857	32737.7857	0.1357	0.71508
Order vs existential	1	11745.0179	11745.0179	0.0487	0.82084
Order vs universal vs existential	1	10368.6429	10368.6429	0.0430	0.83094
EW1B12	52	12548294.0357	241313.3468		
Voice	1	5598257.7857	5598257.7857	30.5269	0.00002
Voice vs universal	1	49147.8750	49147.8750	0.2680	0.61301
Voice vs existential	1	187225.7857	187225.7857	1.0209	0.31809
Voice vs universal vs existential	1	96363.0179	96363.0179	0.5255	0.52144
EW2B12	52	9536157.0357	183387.6353		
Order vs voice	1	17964.4464	17964.4464	0.0687	0.79019
Order vs voice vs universal	1	743.1429	743.1429	0.0028	0.95657
Order vs voice vs existential	1	220629.0179	220629.0179	0.8434	0.63442
Order vs voice vs universal vs exist	1	828631.1429	828631.1429	3.1678	0.07736
EW12B12	52	13602323.7500	261583.1490		
W	168	44279411.5000			

TSQ/N= 1039124071.1429 N= 224 SST= 61028840.8571

APPENDIX 6(h)

Experiment 6 analyses.

Subject data, diagram evaluation time.

SOURCE	DF	SS	MS	F	PROB
SUBJ	29	59160046.2104			
Order	1	6566274.7521	6566274.7521	19.3637	0.00030
EW1B	29	9833980.0604	339102.7607		
Universal	1	1804304.2521	1804304.2521	3.6653	0.06240
EW2B	29	14275660.8104	492264.1659		
Existential	1	2057879.2521	2057879.2521	4.3891	0.04259
EW3B	29	13596904.5604	468858.7779		
Voice	1	1021299.7521	1021299.7521	3.0718	0.08675
EW4B	29	9641824.5604	332476.7090		
Order vs universal	1	23843.1021	23843.1021	0.0505	0.81837
EW12B	29	13701015.7104	472448.8176		
Order vs existential	1	4870.5021	4870.5021	0.0116	0.91126
EW13B	29	12152396.0604	419048.1400		
Order vs voice	1	14377.3521	14377.3521	0.0467	0.82475
EW14B	29	8924002.2104	307724.2142		
Universal vs exist	1	1015956.0188	1015956.0188	3.8932	0.05520
EW23B	29	7567728.7937	260956.1653		
Universal vs voice	1	1556443.5188	1556443.5188	5.8094	0.02129
EW24B	29	7769675.7937	267919.8550		
Existential vs voice	1	2011782.5521	2011782.5521	8.5663	0.00662
EW34B	29	6810629.5104	234849.2935		
Order vs universal vs existential	1	8241.9187	8241.9187	0.0231	0.87474
EW123B	29	10334101.1438	356348.3153		
Order vs universal vs voice	1	3035.1021	3035.1021	0.0139	0.90267
EW124B	29	6312553.9604	217674.2745		
Order vs existential vs voice	1	327868.8021	327868.8021	1.5210	0.22542
EW134B	29	6251100.0104	215555.1728		
Universal vs exist vs voice	1	384257.4187	384257.4187	1.5563	0.22011
EW234B	29	7160332.1438	246908.0050		
Order vs universal vs existential vs voice	1	824.2521	824.2521	0.0028	0.95671

EW1234B	29	8399573.5604	289640.4676
W	450	159532737.4375	

TSQ/N= 1601376569.3521 N= 480 SST= 218692783.6479

APPENDIX 6(i).

Experiment 6 analyses.

Sentence data, evaluation time for diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	55	16200917.3393			
Universal	1	1812960.2857	1812960.2857	7.2412	0.00934
Existential	1	1008754.5714	1008754.5714	4.0291	0.04716
Universal vs exist	1	360162.1607	360162.1607	1.4385	0.23398
EB12	52	13019040.3214	250366.1600		
Order	1	4158895.0179	4158895.0179	19.5110	0.00017
Order vs universal	1	827172.0714	827172.0714	3.8806	0.05126
Order vs existential	1	148526.0000	148526.0000	0.6968	0.58739
Order vs universal vs existential	1	88086.4464	88086.4464	0.4132	0.53015
EW1B12	52	11084109.9643	213155.9609		
Voice	1	1006072.0714	1006072.0714	4.8303	0.03051
Voice vs universal	1	1085036.1607	1085036.1607	5.2094	0.02503
Voice vs existential	1	930090.8750	930090.8750	4.4655	0.03710
Voice vs universal vs existential	1	19687.5000	19687.5000	0.0945	0.75766
EW2B12	52	10830684.8929	208282.4018		
Order vs voice	1	20444.6429	20444.6429	0.0727	0.78469
Order vs voice vs universal	1	11229.4464	11229.4464	0.0399	0.83664
Order vs voice vs existential	1	4590.1607	4590.1607	0.0163	0.89425
Order vs voice vs universal vs existential	1	277770.2857	277770.2857	0.9878	0.67420
EW12B12	52	14622352.9643	281199.0955		
W	168	45114748.5000			

TSQ/N= 808556402.1607 N= 224 SST= 61315665.8393

APPENDIX 7(a).

Materials for Experiment 7.

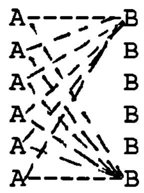
Some dogs chase all foxes.
Some chimps pursue all baboons.
Some recruits admire all sergeants.
Some singers entertain all actors.
Some queens are flattered by all kings.
Some clerks are helped by all secretaries.
Some editors are disliked by all journalists.
Some mules are kicked by all horses.
All sailors impress some captains.
All clowns annoy some ringmasters.
All sparrows chase some blackbirds.
All liars cheat some conmen.
All companies are sued by some solicitors.
All panthers are outrun by some cheetahs.
All playmates are envied by some children.
All dolphins are outswum by some porpoises.
Some jockeys scold every trainer.
Some drivers upset every trafficwarden.
Some swimmers defeat every opponent.
Some farmers oppose every developer.
Some princesses are scorned by every suitor.
Some lecturers are annoyed by every student.
Some ducks are pecked by every seagull.
Some eagles are attacked by every hawk.
Every nurse offends some patients.
Every lawyer persuades some judges.
Every bully fights some schoolboys.
Every girl charms some boys.
Every builder is cheated by some customers.
Every dog chases some foxes.
Every cat is scratched by some kittens.
Every kitten is bitten by some puppy.

APPENDIX 7(b).

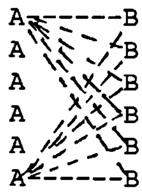
Diagram types for Experiment 7.

```
A------B
A------B
A------B
A------B
A------B
A------B
```

parallel



converging
right



converging
left

APPENDIX 7(c).

Overall results for Experiment 7.

TABLE 7.1 MEAN SCORES FOR DIAGRAMS IN EACH CONDITION. (Scores out of 2).

Sentence Type	Universal 1st				Universal 2nd				MEANS	
Voice	Active		Passive		Active		Passive			
Diagram Type	CON	DIV	CON	DIV	CON	DIV	CON	DIV	CON	DIV
Quantifiers										
All....some(pl)	1.44	1.28	1.78	1.06	2.00	0.22	1.84	0.34	1.76	0.72
Every..some(pl)	1.53	1.03	1.62	1.03	1.78	0.34	1.78	0.47	1.68	0.72
Means	1.48	1.15	1.70	1.04	1.89	0.28	1.81	0.40		

TABLE 7.2 MEAN READING TIMES (MSECS) FOR CONVERGING DIAGRAMS IN EACH CONDITION.

Sentence Type	Universal 1st		Universal 2nd		MEANS
Voice	Active	Passive	Active	Passive	
Diagram Type	CON	CON	CON	CON	
Quantifiers					
All....some(pl)	2404	2189	1923	1994	2127
Every..some(pl)	1894	2163	1942	2135	2033
MEANS	2149	2176	1932	2064	

APPENDIX 7(c) continued.

TABLE 7.3 MEAN EVALUATION TIMES (MSECS) FOR CONVERGING DIAGRAMS IN EACH CONDITION.

Sentence Type	Universal 1st		Universal 2nd		MEANS
Voice	Active	Passive	Active	Passive	
Diagram Type	CON	CON	CON	CON	
Quantifiers					
All....some(pl)	2484	2324	2078	2139	2256
Every..some(pl)	2169	2221	2204	2155	2187
MEANS	2326	2272	2141	2147	

APPENDIX 7(d).

Experiment 7 analyses.
Subject data, diagram scores.

SOURCE	DF	SS	MS	F	PROB
SUBJ	31	22.9922			
Order.	1	8.0000	8.0000	20.4536	0.00022
EW1B	31	12.1250	0.3911		
Universal.	1	0.2813	0.2813	1.4920	0.22926
EW2B	31	5.8438	0.1885		
Voice.	1	0.1953	0.1953	0.7183	0.59216
EW3B	31	8.4297	0.2719		
Diagram.	1	128.0000	128.0000	96.4863	0.00000
EW4B	31	41.1250	1.3266		
Order vs universal.	1	0.1953	0.195	0.9798	0.66890
EW12B	31	6.1797	0.1993		
Order vs voice.	1	0.0313	0.0313	0.1319	0.71939
EW13B	31	7.3438	0.2369		
Order vs diagram.	1	33.0078	33.0078	41.1483	0.00001
EW14B	31	24.8672	0.8022		
Universal vs voice.	1	0.0313	0.0313	0.1161	0.73496
EW23B	31	8.3438	0.2692		
Universal vs diag.	1	0.1953	0.1953	0.9798	0.66890
EW24B	31	6.1797	0.1993		
Voice vs diagram.	1	0.1250	0.1250	0.3163	0.58436
EW34B	31	12.2500	0.3952		
Order vs universal vs voice.	1	0.0703	0.0703	0.2885	0.60120
EW123B	31	7.5547	0.2437		
Order vs universal vs diagram.	1	1.1250	1.1250	4.1029	0.04880
EW124B	31	8.5000	0.2742		
Order vs voice vs diagram.	1	2.2578	2.2578	5.4396	0.02487
EW134B	31	12.8672	0.4151		
Universal vs voice vs diagram.	1	0.1953	0.1953	1.3668	0.25000
EW234B	31	4.4297	0.1429		
Order vs universal vs voice vs diagram.	1	0.7813	0.7813	2.6632	0.10918
EW1234B	31	9.0938	0.2933		

W	480	349.6250			
TSQ/N=	765.3828	N=	512	SST=	372.6172

APPENDIX 7(e).

Experiment 7 analyses.

Sentence data, diagram scores.

SOURCE	DF	SS	MS	F	PROB
SUBJ	29	19.4833			
Universal.	1	0.1500	0.1500	0.2172	0.64932
EB1	28	19.3333	0.6905		
Order.	1	17.0667	17.0667	38.9565	0.00002
Order vs universal.	1	0.4167	0.4167	0.9511	0.66061
EW1B1	28	12.2667	0.4381		
Voice.	1	0.1500	0.1500	0.3549	0.56277
Voice vs universal.	1	0.2667	0.2667	0.6310	0.56065
EW2B1	28	11.8333	0.4226		
Diagram.	1	264.6000	264.6000	617.4000	0.00000
Diagram vs universal	1	0.1500	0.1500	0.3500	0.56549
EW3B1	28	12.0000	0.4286		
Order vs voice.	1	0.0167	0.0167	0.0287	0.86080
Order vs voice vs universal.	1	-0.0000	-0.0000	0.0000	0.99552
EW12B1	28	16.2333	0.5798		
Order vs diagram.	1	64.0667	64.0667	192.2000	0.00000
Order vs diagram vs universal.	1	1.3500	1.3500	4.0500	0.05115
EW13B1	28	9.3333	0.3333		
Voice vs diagram.	1	0.1500	0.1500	0.3549	0.56277
Voice vs diagram vs universal.	1	0.2667	0.2667	0.6310	0.56065
EW23B1	28	11.8333	0.4226		
Order vs voice vs diagram.	1	3.7500	3.7500	3.3404	0.07496
Order vs voice vs diagram vs univ.	1	1.0667	1.0667	0.9502	0.66037
EW123B1	28	31.4333	1.1226		
W	210	458.2500			

TSQ/N= 1540.2667 N= 240 SST= 477.7333

APPENDIX 7(f)

Experiment 7 analyses.

Subject data, reading time for doubly quantified sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	21	113378772.0000			
Order	1	1183096.0227	1183096.0227	2.4703	0.12760
EW1B	21	10057595.9773	478933.1418		
Universal	1	384659.0000	384659.0000	0.6425	0.56275
EW2B	21	12572015.5000	598667.4048		
Voice	1	278409.0909	278409.0909	0.6739	0.57395
EW3B	21	8676162.9091	413150.6147		
Order vs universal	1	1335277.8409	1335277.8409	3.0025	0.09445
EW12B	21	9339159.6591	444721.8885		
Order vs voice	1	122432.7500	122432.7500	0.4275	0.52685
EW13B	21	6014245.2500	286392.6310		
Universal vs voice	1	1013538.2727	1013538.2727	2.1641	0.15294
EW23B	21	9835281.2273	468346.7251		
Order vs universal vs voice	1	359828.2045	359828.2045	0.5089	0.51003
EW123B	21	14848028.2955	707048.9665		
W	154	76019730.0000			

TSQ/N= 761812524.0000 N= 176 SST= 189398502.0000

APPENDIX 7(g).

Experiment 7 analyses.

Sentence data, reading time for doubly quantified sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	27	12015845.5000			
Universal	1	6003.5714	6003.5714	0.0130	0.90616
EB1	26	12009841.9286	461916.9973		
Order	1	172229.1429	172229.1429	0.2488	0.62749
Order vs universal	1	1592703.0000	1592703.0000	2.3008	0.13794
EW1B1	26	17998174.3571	692237.4753		
Voice	1	381655.7500	381655.7500	0.5797	0.54055
Voice vs universal	1	528000.8929	528000.8929	0.8020	0.61774
EW2B1	26	17117222.8571	658354.7253		
Order vs voice	1	137060.0357	137060.0357	0.1766	0.68068
Order vs voice vs universal	1	755385.7500	755385.7500	0.9731	0.66568
EW12B1	26	20182103.7143	776234.7582		
W	84	58864535.5000			

TSQ/N= 595962703.0000 N= 112 SST= 70880381.0000

APPENDIX 7(h).

Experiment 7 analyses.

Subject data, evaluation time for diagrams.

SOURCE	DF	SS	MS	F	PROB
SUBJ	21	60874997.1364			
Order	1	1063931.0000	1063931.0000	2.9020	0.09985
EW1B	21	7699046.7500	366621.2738		
Universal	1	207968.7500	207968.7500	0.4911	0.50235
EW2B	21	8892370.5000	423446.2143		
Voice	1	25488.2045	25488.2045	0.0706	0.78878
EW3B	21	7583805.5455	361133.5974		
Order vs universal	1	868571.0000	868571.0000	1.5901	0.21915
EW12B	21	11470783.7500	546227.7976		
Order vs voice	1	39480.0909	39480.0909	0.0561	0.80983
EW13B	21	14783616.1591	703981.7219		
Universal vs voice	1	28866.5682	28866.5682	0.0820	0.77393
EW23B	21	7391031.1818	351953.8658		
Order vs universal vs voice	1	285131.0000	285131.0000	1.6048	0.21707
EW123B	21	3731237.2500	177677.9643		
W	154	64071327.7500			

TSQ/N= 868899769.1136 N= 176 SST= 124946324.8864

APPENDIX 7(i).

Experiment 7 analyses.

Sentence data, evaluation time for diagrams.

SOURCE	DF	SS	MS	F	PROB
SUBJ	27	10081974.2411			
Universal	1	3487.7232	3487.7232	0.0090	0.92223
EB1	26	10078486.5179	387634.0968		
Order	1	158326.0804	158326.0804	0.5154	0.51417
Order vs universal	1	216920.0089	216920.0089	0.7061	0.58684
EW1B1	26	7987121.6607	307196.9870		
Voice	1	26691.4375	26691.4375	0.0472	0.82405
Voice vs universal	1	4488.2232	4488.2232	0.0079	0.92708
EW2B1	26	14700799.0893	565415.3496		
Order vs voice	1	2014.5089	2014.5089	0.0071	0.93092
Order vs voice vs universal	1	264325.7232	264325.7232	0.9376	0.65638
EW12B1	26	7330178.5179	281929.9430		
W	84	30690865.2500			

TSQ/N= 562414807.5089 N= 112 SST= 40772839.4911

APPENDIX 8(a).

Materials for Experiment 8.

List A.

Susan gave a recipe to some friends.
Martin sold a book to some students.
Paula delivered a present to some neighbours.
Peter donated a jumper to some charities.
Mary told a story to some children.
Simon gave a sweet to some girls.
Josie sent a letter to some relatives.
James handed a ticket to some shoppers.
Margaret served a scone to some customers.
Kevin lent a crayon to some pupils.
Malcolm passed a glass to several students.
Christine threw a frisbee to several children.
Steve presented a trophy to several competitors.
Cathy handed a cigarette to several friends.
Ray kicked a ball to several players.
Marion issued a writ to several editors.
Paul wrote a memo to several secretaries.
Sally offered a job to several girls.
Neil rented a flat to several students.
Heather cooked a steak for several visitors.
Maisie returned a gift to many people.
Matthew snatched a bag from many shoppers.
Gillian collected a ticket from many spectators.
Arthur left a key with many friends.
Angela bought a present for many relatives.
Charlie bought a tie from many salesmen.
Charlotte confiscated a package from many schoolboys.
Derek seized a camera from many bystanders.
Alison took a gift to many pensioners.
David delivered a lecture to many scholars.
Eleanor pitched a ball to most players.
Graham handed a book to most prisoners.
Shirley prepared a report for most managers.
Brian read a poem to most children.
Tracy presented a prize to most sportsmen.
Jeff loaned a key to most guests.
Rose took a plant to most gardeners.
Gary begged a loan from most neighbours.
Claire accepted a job from most interviewers.
Nick lent a record to most students.
Katie made a mascot for all supporters.
Phillip requested a plan from all architects.
Vicky cut a pattern for all dressmakers.
Bob suggested a schedule for all teachers.
Diana proposed a scheme to all politicians.
Mark carried a bag for all passengers.
Ann gave a reprimand to all boys.
Richard sent a note to all doctors.
Sarah devised a test for all students.
Andrew drew a diagram for all planners.
Fiona claimed a reward from every policeman.
Anthony created a sketch for every designer.

APPENDIX 8(a) continued.

Helen typed a schedule for every delegate.
Sean displayed a picture to every collector.
Emily wrote a script for every presenter.
Carl took a photograph of every tourist.
Gail accepted a present from every classmate.
Fred sent a timetable for every driver.
Linda prepared a form for every voter.
Michael examined a project from every candidate.
Melanie got a postcard from each traveller.
Edward launched a campaign for each advertiser.
Liz reported an incident to each officer.
Alan charged a fee for each golfer.
Betty fixed a bonus for each worker.
Joe set a topic for each pupil.
Carol made a tent for each woman.
Jeremy served a lobster to each diner.
Judy loaned a book to each guest.
Justin sent a letter to each candidate.

List B.

Susan gave some friends a recipe.
Martin sold some students a book.
Paula sent some neighbours a present.
Peter gave some charities a jumper.
Mary told some children a story.
Simon gave some girls a sweet.
Josie sent some relatives a letter.
James handed some shoppers a ticket.
Margaret served some customers a scone.
Kevin lent some pupils a crayon.
Malcolm passed several students a glass.
Christine threw several children a frisbee.
Steve gave several competitors a trophy.
Cathy handed several friends a cigarette.
Ray passed several players a ball.
Marion sent several editors a writ.
Paul wrote several secretaries a memo.
Sally offered several girls a job.
Neil rented several students a flat.
Heather cooked several visitors a steak.
Maisie left many people a gift.
Matthew gave many shoppers a bag.
Gillian gave many spectators a ticket.
Arthur sent many friends a key.
Angela bought many relatives a present.
Charlie bought many soldiers a uniform.
Charlotte took many schoolboys a package.
Derek showed many bystanders a camera.
Alison took many pensioners a gift.
David gave many scholars a lecture.
Eleanor threw most players a ball.
Graham handed most prisoners a book.
Shirley left most managers a report.
Brian read most children a poem.

Tracy gave most sportsmen a prize.
Jeff loaned most guests a key.
Rose took most gardeners a plant.
Gary gave most neighbours a loan.
Claire left most interviewers a note.
Nick lent most students a record.
Katie made all supporters a mascot.
Phillip gave all architects a plan.
Vicky cut all dressmakers a pattern.
Bob left all teachers a schedule.
Diana told all politicians a scheme.
Mark handed all passengers a bag.
Ann gave all boys a reprimand.
Richard sent all doctors a note.
Sarah set all students a test.
Andrew drew all planners a diagram.
Fiona left every policeman a reward.
Anthony showed every designer a sketch.
Helen typed every delegate a schedule.
Sean showed every collector a picture.
Emily wrote every presenter a script.
Carl handed every tourist a photograph.
Gail took every classmate a present.
Fred sent every driver a timetable.
Linda sent every voter a form.
Michael set every candidate a project.
Melanie sent each traveller a postcard.
Edward gave each advertiser a campaign.
Liz gave each officer a report.
Alan charged each golfer a fee.
Betty fixed each worker a bonus.
Joe set each pupil a topic.
Carol made each woman a tent.
Jeremy served each diner a lobster.
Judy loaned each guest a book.
Justin sent each candidate a letter.

APPENDIX 8(b).

Overall results for Experiment 8.

TABLE 8.1 MEAN NUMBER OF CONVERGING AND DIVERGING DIAGRAMS CHOSEN IN EACH CONDITION. (Scores out of 5)

Sentence Type	Universal 1st		Universal 2nd		MEANS	
Diagram Type	CON	DIV	CON	DIV	CON	DIV
Quantifiers						
some	4.30	3.21	3.46	3.89	3.88	3.55
several	4.14	3.87	3.16	4.02	3.65	3.94
many	4.12	3.73	3.23	4.14	3.67	3.93
most	3.95	4.50	2.89	4.21	3.42	4.35
all	3.98	4.10	3.07	4,16	3.52	4.13
every	3.62	4.62	2.86	4.46	3.24	4.54
each	3.32	4.68	2.21	4.46	2.76	4.57
MEANS	3.92	4.10	2.98	4.19		

TABLE 8.2 MEAN READING TIME (MSECS) FOR DOUBLY QUANTIFIED SENTENCE IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type	DIV	DIV	DIV
Quantifiers			
some	2050	2282	2166
several	2156	2439	2297
many	1918	2417	2167
most	1940	2239	2089
all	2015	2468	2241
every	2013	2268	2140
each	1964	2314	2139
MEANS	2008	2347	

APPENDIX 8(b) continued.

TABLE 8.3 EVALUATION TIME (MSECS) FOR DIVERGING DIAGRAM IN EACH CONDITION.

Sentence Type	UNIVERSAL 1ST	UNIVERSAL 2ND	MEANS
Diagram Type	DIV	DIV	DIV
Quantifiers			
some	1744	1842	1793
several	1473	1654	1563
many	1522	1634	1578
most	1362	1658	1510
all	1295	1822	1558
every	1181	1303	1242
each	1364	1406	1385
MEANS	1420	1617	

APPENDIX 8(c).

Experiment 8 analyses.

Subject data, YES responses to diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	111	804.6327			
Order.	1	70.2959	70.2959	10.5300	0.00194
EB1	110	734.3367	6.6758		
Quantifier.	6	9.1862	1.5310	1.5498	0.15853
Quantifier vs order.	6	15.0969	2.5162	2.5470	0.01896
EW1B1	660	652.0026	0.9879		
Diagram.	1	190.1250	190.1250	33.2970	0.00001
Diagram vs order.	1	103.0638	103.0638	18.0498	0.00016
EW2B1	110	628.0969	5.7100		
Quantifier vs diag.	6	171.7857	28.6310	27.8858	0.00000
Quant. vs diag. vs order.	6	8.2934	1.3822	1.3463	0.23331
EW12B1	660	677.6352	1.0267		
W	1456	2455.2857			

TSQ/N= 22654.0816 N= 1568 SST= 3259.9184

Sentence data, YES responses to diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	106.8980			
Order.	1	1.7163	1.7163	2.4710	0.11662
EW1B	69	47.9265	0.6946		
Quantifier.	6	72.6694	12.1116	21.3654	0.00000
EW2B	414	234.6878	0.5669		
Diagram.	1	44.7020	44.7020	8.0009	0.00621
EW3B	69	385.5122	5.5871		
Order vs quantifier.	6	215.0837	35.8473	64.1698	0.00000
EW12B	414	231.2735	0.5586		
Order vs diagram.	1	233.1510	233.1510	210.3155	0.00000
EW13B	69	76.4918	1.1086		
Quantifier vs diag.	6	285.8837	47.6473	63.6523	0.00000
EW23B	414	309.9020	0.7486		
Order vs quant. vs diagram.	6	196.7347	32.7891	49.7930	0.00000
EW123B	414	272.6224	0.6585		

APPENDIX 8(c) continued.

W	1890	2608.3571

TSQ/N= 16634.7449 N= 1960 SST= 2715.2551

APPENDIX 8(d).

Experiment 8 analyses.

Subject data, reading time for sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	99	473229653.0557			
Order	1	20071531.5557	20071531.5557	4.3407	0.03742
EB1	98	453158121.5000	4624062.4643		
Quantifier	6	2929411.3371	488235.2229	0.9958	0.57219
Quantifier vs order	6	1550208.1143	258368.0190	0.5270	0.78968
EW1B1	588	288280405.1200	490272.7978		
W	600	292760024.5714			

TSQ/N= 3319189381.3729 N= 700 SST= 765989677.6271

Sentence data, reading time for sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	65	37213618.7846			
Order	1	149334156.2435	149334156.2435	333.8741	0.00000
EW1B	65	29072994.5422	447276.8391		
Quantifier	6	4059444.1039	676574.0173	1.0948	0.36461
EW2B	390	241021953.7532	618005.0096		
Order vs quantifier	6	5627279.9004	937879.9834	1.8694	0.08419
EW12B	390	195662348.8139	501698.3303		
W	858	624778177.3571			

TSQ/N= 3172406418.8582 N= 924 SST= 661991796.1418

APPENDIX 8(e).

Experiment 8 analyses.

Subject data, evaluation time for diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	99	288057630.1486			
Order	1	6796697.9657	6796697.9657	2.3682	0.12308
EB1	98	281260932.1829	2870009.5121		
Quantifier	6	17686301.9943	2947716.9990	8.4194	0.00000
Order vs quantifier	6	4151867.1543	691977.8590	1.9765	0.06637
EW1B1	588	205865191.1371	350110.8693		
W	600	227703360.2857			

TSQ/N= 1614350767.5657 N= 700 SST= 515760990.4343

Sentence data, evaluation time for diagram.

SOURCE	DF	SS	MS	F	PROB
SUBJ	65	31106770.3171			
Order	1	5152448.0530	5152448.0530	11.4289	0.00159
EW1B	65	29303662.1613	450825.5717		
Quantifier	6	16868144.8745	2811357.4791	5.8237	0.00005
EW2B	390	188270468.5541	482744.7912		
Order vs quantifier	6	2633815.1818	438969.1970	0.8326	0.54646
EW12B	390	205612089.1039	527210.4849		
W	858	447840627.9286			

TSQ/N= 2150527866.7543 N= 924 SST= 478947398.2457

APPENDIX 9(a).

Materials for Experiment 9.

Susan gave a recipe to some friends.
They were pleased to get it.
Did Susan like cooking?

Martin sold a book to some students.
They were happy to buy it.
Did Martin like reading?

Paula delivered a present to some neighbours.
They were delighted to receive it.
Was Paula thoughtful?

Peter donated a jumper to some charities.
They were grateful to have it.
Was Peter stingy?

Mary told a story to some children.
They were glad to hear it.
Did the children listen?

Simon gave a sweet to some girls.
They were quick to taste them.
Was Simon greedy?

Josie sent a letter to some relatives.
They were surprised to get them.
Did Josie write often?

James handed a leaflet to some shoppers.
They were reluctant to take them.
Was James popular?

Margaret served a cake to some customers.
They were eager to eat them.
Was Margaret a good cook?

Kevin lent a crayon to some pupils.
They were anxious to borrow them.
Was the class drawing?

Malcolm passed a drink to several players.
They were surprised to get it.
Did Malcolm like drinking?

Christine threw a frisbee to several children.
They were playing with it.
Was Christine energetic?

Steve presented a cup to several competitors.
They were delighted to get it.
Did Steve present a shield?

APPENDIX 9(a) continued.

Cathy tossed a cigarette to several friends.
They were quick to catch it.
Did Cathy smoke?

Ray bowled a ball to several cricketers.
They ran to hit it.
Was Ray a fielder?

Marion issued a writ to several editors.
They vigorougly opposed them.
Was Marion angry?

Paul wrote a memo to several secretaries.
They were annoyed about them.
Was Paul the boss?

Sally offered a lift to several girls.
They were glad to accept them.
Was Sally kind-hearted?

Neil rented a flat to several students.
They were pleased to get them.
Was Neil a landlord?

Heather cooked a meal for several visitors.
They rushed to eat them.
Were the visitors hungry?

Masie returned a gift to many people.
They were shocked to get it.
Was Masie jilted?

Matthew snatched a bag from many pedestrians.
They were angry at losing it.
Was Matthew a thief?

Kerry collected a fee from many spectators.
They were unwilling to pay it.
Did Kerry work hard?

Arthur left a key with many friends.
They were anxious about it.
Did Arthur go on holiday?

Angela bought a present for many relatives.
They did not like it.
Was Angela unkind?

Leo hired a boat from many salesmen.
They competed to rent them.
Was Leo a keen sailor?

Charlotte confiscated a package from many schoolboys.
They were sorry to lose them.
Was Charlotte strict?

APPENDIX 9(a) continued.

Derek seized a camera from many bystanders.
They tried to grab them.
Was Derek honest?

Alison took a parcel to many pensioners.
They were grateful to get them.
Was Alison a thoughtless person?

David delivered a lecture to many scholars.
They were interested to hear them.
Was David a competent lecturer?

Eleanor pitched a ball to most batsmen.
They managed to hit it.
Was Eleanor a proficient bowler?

Graham handed a book to most prisoners.
They wanted to read it.
Was Graham a librarian?

Shirley made a report for most managers.
They were dissatisfied with it.
Was Shirley a secretary?

Brian saved a ball from most fielders.
They were glad he caught it.
Was Brian a swimmer?

Tracey presented a prize to most sportsmen.
They gratefully accepted it.
Did Tracey make a speech?

Jeff stole a watch from most guests.
They were furious at losing them.
Was Jeff dishonest?

Rose took a plant to most gardeners.
They wanted to examine them.
Was Rose a botanist?

Gary grabbed a biscuit from most neighbours.
They were about to eat them.
Was Gary a glutton?

Clare accepted a job from most firms.
They were quick to offer them.
Was Clare a good worker?

Nick borrowed a record from most students.
They were reluctant to lend them.
Was Nick careful with possessions?

Katy prepared a report for all members.
They were unahppy about it.
Was Katy conscientious?

APPENDIX 9(a) continued.

Phillip requested a plan from all architects.
They were quick to supply it.
Was Phillip a builder?

Vicky cut a pattern for all dressmakers.
They were very satisfied with it.
Was Vicky a seamstress?

Bob suggested a schedule for all teachers.
They were delighted with it.
Was Bob a headmaster?

Dianna proposed a scheme to all politicians.
They were worried about postponing it.
Was Diana a cook?

Mark carried a bag for all passengers.
They were anxious to retrieve them.
Was Mark careless?

Ann gave a cake to all patients.
They were slow to eat them.
Was Ann a good baker?

Charles left a rose for all nurses.
They were flattered to get them.
Was Charles ungrateful?

Sarah devised a test for all schoolchildren.
They were unwilling to take them.
Was Sarah a teacher?

Andrew drew a diagram for all planners.
They were confused by them.
Was Andrew good at drawing?

Fiona claimed a reward from every policeman.
They were pleased to give it.
Was Fiona a trustworthy person?

Anthony created a sketch for every designer.
They were amazed at the style of it.
Was Anthony bad at sketching?

Helen gave an agenda to every delegate.
They began to read it.
Was Helen efficient?

Sian displayed a picture to every collector.
They wanted to buy it.
Was Sian an artist?

APPENDIX 9(a) continued.

Emily wrote a script for every presenter.
They were eager to read it.
Was Emily illiterate?

Carl sold a trinket to every tourist.
They were impressed by them.
Was Carl a sculptor?

Gail pinched an apple from every classmate.
They were surprised to lose them.
Was Gail kind?

Fred send a timetable to every driver.
They rushed to look at them.
Was Fred a bus conductor?

Linda prepared a poll card for every voter.
They carefully examined them.
Was Linda a blacksmith?

Michael examined an essay from every graduate.
They were happy to submit them.
Was Michael a popular teacher?

Melanie got a card from each traveller.
They remembered to send it.
Was Melanie a tourist?

Edward designed a campaign for each advertiser.
They were impatient to get it.
Was Edward a slow worker?

Liz reported an incident to each officer.
They were surprised to hear of it.
Was Liz a vigilant person?

Alan charged a fee to each golfer.
They were reluctant to pay it.
Was Alan greedy?

Betty fixed a rate for each worker.
They were grateful to get it.
Was Betty unfair?

Joe set a project for each pupil.
They complained at getting them.
Was Joe a carpenter?

APPENDIX 9(a) continued.

Carol sewed a gown for each woman.
They were reticent about wearing them.
Was Carol a pilot?

Judy wrote an invitation to each guest.
They were amazed to receive them.
Was Judy a sociable person?

Jeremy carved a joint for each diner.
They were surprised at the weight of them.
Was Jeremy a waiter?

Justin sent a letter to each candidate.
They were overjoyed to have them.
Was Justin an examiner?

APPENDIX 9(b).

Experiment 9 analyses.

Subject data, reading time for first sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	267845801.1673			
Quantifier.	6	2354236.2816	392372.7136	2.0248	0.06062
EW1B	414	80227038.2898	193785.1166		
Continuation.	1	660817.0449	660817.0449	3.5697	0.05978
EW2B	69	12773033.6694	185116.4300		
Quantifier vs continuation.	6	702176.7265	117029.4544	0.6613	0.68338
EW12B	414	73267693.5592	176975.1052		
W	910	169984995.5714			

TSQ/N= 3404581101.2612 N= 980 SST= 437830796.7388

Sentence data, reading time for first sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	64880192.1888			
Quantifier.	6	2340558.4673	390093.0779	1.9432	0.07202
EW1B	414	83110161.5327	200749.1824		
Continuation.	1	590255.7153	590255.7153	2.6162	0.10642
EW2B	69	15567317.0704	225613.2909		
Quantifier vs continuation.	6	653611.8918	108935.3153	0.5372	0.78172
EW12B	414	83945465.8224	202766.8257		
W	910	186207370.5000			

TSQ/N= 3468996814.3112 N= 980 SST= 251087562.6888

APPENDIX 9(c).

Experiment 9 analyses.

Subject data, reading time for continuation sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	95332244.8531			
Quantifier.	6	276428.3673	46071.3946	0.9749	0.55734
EW1B	414	19565350.7755	47259.3014		
Continuation.	1	1466343.3306	1466343.3306	25.4256	0.00004
EW2B	69	3979362.3837	57671.9186		
Quantifier vs continuation.	6	559428.7265	93238.1211	2.1896	0.04257
EW12B	414	17629133.5592	42582.4482		
W	910	43476047.1429			

TSQ/N= 1227113304.0041 N= 980 SST= 138808291.9959

Sentence data, reading time for continuation sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	26146603.3888			
Quantifier.	6	259763.1245	43293.8541	0.7908	0.57912
EW1B	414	22665916.4469	54748.5905		
Continuation.	1	1541631.7969	1541631.7969	22.6648	0.00007
EW2B	69	4693298.4173	68018.8176		
Quantifier vs continuation.	6	518159.0102	86359.8350	1.7796	0.10106
EW12B	414	20090046.2755	48526.6818		
W	910	49768815.0714			

TSQ/N= 1257297000.5398 N= 980 SST= 75915418.4602

APPENDIX 10(a).

Materials for Experiment 10.

List A.

Susan gave a recipe to some friends.
The recipe was for Hungarian goulash.
Was Susan a cook?

Martin sold a book to some students.
The book was about flying planes.
Was Martin a butcher?

Paula delivered a present to some neighbours.
The present was for Christmas Day.
Was Paula kind-hearted?

Peter donated a coat to some charities.
The coat was very old indeed.
Was Peter a thoughtless person?

Mary told a story to some children.
The story was about sailing boats.
Was Mary good with children?

Simon gave a sweet to some girls.
The sweets were wrapped in paper.
Was Simon mean?

Josie sent a letter to some relatives.
The letters were hard to write.
Was Josie illiterate?

James handed a ticket to some shoppers.
The tickets were for tomorrow's raffle.
Did James hand out leaflets?

Margaret served a scone to some customers.
The scones were hard and dry.
Was Margaret a waitress?

Kevin lent a crayon to some pupils.
The crayons were completely worn down.
Was Kevin generous?

Malcolm passed a glass to several students.
The glass was full of beer.
Was Malcolm teetotal?

Christine threw a frisbee to several children.
The frisbee was bright red plastic.
Was Christine lazy?

Steve presented a cup to several competitors.
The cup was made of silver.
Was Steve the Mayor?

Cathy handed a cigarette to several friends.
The cigarette was soggy and bent.
Did Cathy smoke?

Ray kicked a ball to several players.
The ball was way off course.
Was Ray good at football?

Marion issued a writ to several editors.
The writs were for different offences.
Was Marion angry?

Paul wrote a memo to several secretaries.
The memos were varying in tone.
Was Paul a lorry driver?

Sally offered a job to several girls.
The jobs were in local hotels.
Was Sally an interviewer?

Neil rented a flat to several students.
The flats were very badly decorated.
Was Neil a landlord?

Heather cooked a steak for several visitors.
The steaks were served with mushrooms.
Was Heather a good cook?

Masie returned a gift to many people.
The gift was not very suitable.
Was Masie ungrateful?

Matthew snatched a bag from many shoppers.
The bag was full of money.
Was Matthew a thief?

Gillian collected a ticket from many spectators.
The ticket was free of charge.
Was Gillian working?

Arthur left a key with many friends.
The key was made of brass.
Did Arthur go on holiday?

Angela bought a present for many relatives.
The present was very good quality.
Was Angela mean?

Charlie bought a shirt from many salesmen.
The shirts were striped or checked.
Did Charlie buy a tie?

Charlotte confiscated a package from many schoolboys.
The packages were full of drugs.
Was Charlotte a teacher?

APPENDIX 10(a) continued.

Derek seized a camera from many bystanders.
The cameras were very expensive makes.
Was Derek an honest person?

Alison took a parcel to many pensioners.
The parcels were tied with string.
Was Alison stingy?

David delivered a lecture to many scholars.
The lectures were on diverse topics.
Was David a lecturer?

Eleanor pitched a ball to most batsmen.
The ball was far too soft.
Was Eleanor lazy?

Graham handed a book to most prisoners.
The book was on short loan.
Was Graham a warder?

Shirley prepared a report for most managers.
The report was about promotion prospects.
Was Shirley a secretary?

Brian read a poem to most children.
The poem was a particular favourite.
Did Brian like poetry?

Tracy presented a prize to most sportsmen.
The prize was a crystal bowl.
Did Tracy like sport?

Jeff loaned a key to most guests.
The keys were for the bedrooms.
Was Jeff a hotelier?

Rose took a plant to most gardeners.
The plants were very rare species.
Was Rose a botanist?

Gary begged a loan from most neighbours.
The loans were for gambling debts.
Was Gary in difficulties?

Claire accepted a job from most interviewers.
The jobs were in different towns.
Did Claire need a job?

Nick lent a record to most students.
The records were difficult to buy.
Did Nick like music?

APPENDIX 10(a) continued.

Katie made a mascot for all members.
The mascot was made from wood.
Was Katie knitting?

Phillip requested a plan from all architects.
The plan was difficult to devise.
Was Phillip a builder?

Vicky cut a pattern for all dressmakers.
The pattern was torn in half.
Was Vicky a designer?

Bob suggested a schedule for all teachers.
The schedule was adopted at once.
Was Bob inefficient?

Diana proposed a scheme to all politicians.
The scheme was for new road works.
Was Diana a politician?

Mark carried a bag for all passengers.
The bags were of varied weights.
Was Mark a porter?

Ann gave a reprimand to all boys.
The reprimands were for different offences.
Was Ann a teacher?

Richard sent a note to all nurses.
The notes were about separate wards.
Was Richard a doctor?

Sarah devised a test for all students.
The tests were filled in independently.
Was Sarah a hairdresser?

Andrew drew a diagram for all planners.
The diagrams were for contrasting designs.
Was Andrew an illustrator?

Fiona claimed a reward from every policeman.
The reward was presented in public.
Was Fiona honest?

Anthony created a sketch for every designer.
The sketch was of excellent quality.
Was Anthony good at drawing?

Helen typed a schedule for every delegate.
The schedule was put on display.
Was Helen a typist?

Sean displayed a picture to every collector.
The picture was of great value.
Was Sean an art dealer?

APPENDIX 10(a) continued.

Emily wrote a script for every presenter.
The script was stained with coffee.
Was Emily a writer?

Carl took a photograph of every tourist.
The photographs were of varying quality.
Was Carl a proficient photographer?

Gail accepted a present from every classmate.
The presents were little wooden toys.
Was Gail leaving school?

Fred sent a timetable for every driver.
The timetables were for different routes.
Was Fred an administrator?

Linda prepared a form for every voter.
The forms were written by hand.
Did Linda work hard?

Michael examined a project from every candidate.
The projects were of varying standards.
Was Michael a teacher?

Melanie got a postcard from each traveller.
The postcard was late in arriving.
Was Melanie popular?

Edward launched a campaign for each advertiser.
The campaign was one week long.
Was Edward a salesman?

Liz reported an incident to each officer.
The incident was shocking and frightening.
Was Liz afraid?

Alan charged a fee for each golfer.
The fee was for the group.
Was Alan a groundsman?

Betty fixed a bonus for each worker.
The bonus was shared out equally.
Was Betty the boss?

Joe set a project for each pupil.
The projects were handed in separately.
Was Joe a pupil?

Carol made a tent for each woman.
The tents were much too small.
Was Carol good at her job?

Jeremy served a lobster to each diner.
The lobsters were succulent and tasty.
Was Jeremy a waiter?

Judy loaned a book to each guest.
The books were by women writers.
Was Judy a guitarist?

Justin sent a letter to each candidate.
The letters were contrasting in tone.
Was Justin illiterate?

List B.
Susan gave some friends a recipe.
The recipe was for Hungarian goulash.
Was Susan a cook?

Martin sold some students a book.
The book was about flying planes.
Was Martin a butcher?

Paula sent some neighbours a present.
The present was for Christmas Day.
Was Paula kind-hearted?

Peter gave some charities a coat.
The coat was very old indeed.
Was Peter a thoughtless person?

Mary told some children a story.
The story was about sailing boats.
Was Mary good with children?

Simon gave some girls a sweet.
The sweets were wrapped in paper.
Was Simon mean?

Josie sent some relatives a letter.
The letters were hard to write.
Was Josie illiterate?

James handed some shoppers a ticket.
The tickets were for tomorrow's raffle.
Did James hand out leaflets?

Margaret served some customers a scone.
The scones were hard and dry.
Was Margaret a waitress?

Kevin lent some pupils a crayon.
The crayons were completely worn down.
Was Kevin generous?

Malcolm passed several students a glass.
The glass was full of beer.
Was Malcolm teetotal?

Christine threw several children a frisbee.
The frisbee was bright red plastic.
Was Christine lazy?

Steve gave several competitors a cup.
The cup was made of silver.
Was Steve the Mayor?

Cathy handed several friends a cigarette.
The cigarette was soggy and bent.
Did Cathy smoke?

Ray passed several players a ball.
The ball was way off course.
Was Ray good at football?

Marion sent several editors a writ.
The writs were for different offences.
Was Marion angry?

Paul wrote several secretaries a memo.
The memos were varying in tone.
Was Paul a lorry driver?

Sally offered several girls a job.
The jobs were in local hotels.
Was Sally an interviewer?

Neil rented several students a flat.
The flats were very badly decorated.
Was Neil a landlord?

Heather cooked several visitors a steak.
The steaks were served with mushrooms.
Was Heather a good cook?

Masie left many people a gift.
The gift was not very suitable.
Was Masie kind?

Matthew gave many shoppers a bag.
The bag was full of flour.
Was Matthew a thief?

Gillian gave many spectators a ticket.
The ticket was free of charge.
Was Gillian working?

Arthur sent many friends a key.
The key was made of brass.
Did Arthur go on holiday?

APPENDIX 10(a) continued.

Angela bought many relatives a present.
The present was very good quality.
Was Angela mean?

Charlie bought many salesmen a uniform.
The uniforms were striped or checked.
Did Charlie buy a tie?

Charlotte took many schoolboys a package.
The packages were full of drugs.
Was Charlotte a teacher?

Derek showed many bystanders a camera.
The cameras were very expensive makes.
Was Derek an honest person?

Alison took many pensioners a parcel.
The parcels were tied with string.
Was Alison stingy?

David gave many scholars a lecture.
The lectures were on diverse topics.
Was David a lecturer?

Eleanor threw most batsmen a ball.
The ball was far too soft.
Was Eleanor lazy?

Graham handed most prisoners a book.
The book was on short loan.
Was Graham a warder?

Shirley left most managers a report.
The report was about promotion prospects.
Was Shirley a secretary?

Brian read most children a poem.
The poem was a particular favourite.
Did Brian like poetry?

Tracy gave most sportsmen a prize.
The prize was a crystal bowl.
Did Tracy like sport?

Jeff loaned most guests a key.
The keys were for the bedrooms.
Was Jeff a hotelier?

Rose took most gardeners a plant.
The plants were very rare species.
Was Rose a botanist?

APPENDIX 10(a) continued.

Gary gave most neighbours a loan.
The loans were for gambling debts.
Was Gary in difficulties?

Claire left most interviewers a note.
The notes were in different inks.
Did Claire need a job?

Nick lent most students a record.
The records were difficult to buy.
Did Nick like music?

Katie made all members a mascot.
The mascot was made from wood.
Was Katie knitting?

Phillip gave all architects a plan.
The plan was difficult to devise.
Was Phillip a builder?

Vicky cut all dressmakers a pattern.
The pattern was torn in half.
Was Vicky a designer?

Bob left all teachers a schedule.
The schedule was adopted at once.
Was Bob inefficient?

Diana told all politicians a scheme.
The scheme was for new road works.
Was Diana a politician?

Mark handed all passengers a bag.
The bags were of varied weights.
Was Mark a porter?

Ann gave all boys a reprimand.
The reprimands were for different offences.
Was Ann a teacher?

Richard sent all nurses a note.
The notes were about separate wards.
Was Richard a doctor?

Sarah set all students a test.
The tests were filled in independently.
Was Sarah a hairdresser?

Andrew drew all planners a diagram.
The diagrams were for contrasting designs.
Was Andrew an illustrator?

Fiona left every policeman a reward.
The reward was presented in public.
Was Fiona honest?

APPENDIX 10(a) continued.

Anthony showed every designer a sketch.
The sketch was of excellent quality.
Was Anthony good at drawing?

Helen typed every delegate a schedule.
The schedule was put on display.
Was Helen a typist?

Sean showed every collector a picture.
The picture was of great value.
Was Sean an art dealer?

Emily wrote every presenter a script.
The script was stained with coffee.
Was Emily a writer?

Carl handed every tourist a photograph.
The photographs were of varying quality.
Was Carl a proficient photographer?

Gail took every classmate a present.
The presents were little wooden toys.
Was Gail leaving school?

Fred sent every driver a timetable.
The timetables were for different routes.
Was Fred an administrator?

Linda sent every voter a form.
The forms were written by hand.
Did Linda work hard?

Michael set every candidate a project.
The projects were of varying standards.
Was Michael a teacher?

Melanie sent each traveller a postcard.
The postcard was late in arriving.
Was Melanie popular?

Edward gave each advertiser a campaign.
The campaign was one week long.
Was Edward a salesman?

APPENDIX 10(a) continued.

Liz gave each officer a report.
The report was very badly written.
Was Liz afraid?

Alan charged each golfer a fee.
The fee was for the group.
Was Alan a groundsman?

Betty fixed each worker a bonus.
The bonus was shared out equally.
Was Betty the boss?

Joe set each pupil a project.
The projects were handed in separately.
Was Joe a pupil?

Carol made each woman a tent.
The tents were much too small.
Was Carol good at her job?

Jeremy served each diner a lobster.
The lobsters were succulent and tasty.
Was Jeremy a waiter?

Judy loaned each guest a book.
The books were by women writers.
Was Judy a guitarist?

Justin sent each candidate a letter.
The letters were contrasting in tone.
Was Justin illiterate?

APPENDIX 10(b).

Experiment 10 analyses.

Subject data, reading time for first sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	139	1328396038.1525			
Order.	1	48334964.7189	48334964.7189	5.2109	0.02255
EB1	138	1280061073.4336	9275804.8800		
Quantifier.	6	7956253.2418	1326042.2070	7.3769	0.00001
Quantifier vs order.	6	445389.5561	74231.5927	0.4130	0.87117
EW1B1	828	148838376.0592	179756.4928		
Continuation.	1	312607.6577	312607.6577	1.1524	0.28473
Continuation vs order.	1	170992.9842	170992.9842	0.6303	0.56557
EW2B1	138	37435692.2867	271273.1325		
Quantifier vs continuation.	6	1083251.0316	180541.8386	0.9151	0.51558
Quantifier vs cont. vs order.	6	779931.0194	129988.5032	0.6588	0.68540
EW12B1	828	163366070.5204	197302.0175		
W	1820	360388564.3572			

TSQ/N= 8389757766.4903 N= 1960 SST=1688784602.5097

Sentence data, reading time for first sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	45497962.7352			
Order.	1	49974921.8577	49974921.8577	162.8821	0.00000
EW1B	69	21170336.5352	306816.4715		
Quantifier.	6	7455471.5316	1242578.5886	3.0538	0.00646
EW2B	414	168457011.1112	406900.9930		
Continuation.	1	377164.1434	377164.1434	0.9822	0.67394
EW3B	69	26496545.8209	384007.9104		
Order vs quantifier.	6	381981.2602	63663.5434	0.2369	0.96312
EW12B	414	111246200.0969	268710.6283		
Order vs cont.	1	147744.0250	147744.0250	1.0149	0.31838
EW13B	69	10044770.9393	145576.3904		
Quantifier vs cont.	6	1141372.1888	190228.6981	0.5663	0.75922
EW23B	414	139071152.5969	335920.6584		

APPENDIX 10(b) continued.

Order vs quantifier vs continuation.	6	655039.8071	109173.3012	0.3825	0.89030
EW123B	414	118154207.9786	285396.6376		
W	1890	654773919.8929			

TSQ/N= 8399509416.3719 N= 1960 SST= 700271882.6281

APPENDIX 10(c).

Experiment 10 analyses.

Subject data, reading time for continuation sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	139	421484544.5531			
Order.	1	1094948.1000	1094948.1000	0.3594	0.55697
EB1	138	420389596.4531	3046301.4236		
Quantifier.	6	233308.1245	38884.6874	0.4992	0.81068
Quantifier vs order.	6	262792.0143	43798.6690	0.5622	0.76257
EW1B1	828	64501698.4327	77900.6020		
Continuation.	1	2139458.9469	2139458.9469	31.2044	0.00001
Continuation vs order.	1	9241.6000	9241.6000	0.1348	0.71519
EW2B1	138	9461651.4531	68562.6917		
Quantifier vs cont.	6	736971.3102	122828.5517	1.6420	0.13176
Quantifier vs cont. vs order.	6	370733.8571	61788.9762	0.8260	0.55119
EW12B1	828	61938784.8327	74805.2957		
W	1820	139654640.5714			

TSQ/N= 3980441110.8755 N= 1960 SST= 561139185.1245

Sentence data, reading time for continuation sentence.

SOURCE	DF	SS	MS	F	PROB
SUBJ	69	28372630.7250			
Order.	1	990585.6985	990585.6985	13.0535	0.00088
EW1B	69	5236192.1944	75886.8434		
Quantifier.	6	252259.1643	42043.1940	0.2940	0.93902
EW2B	414	59209993.3357	143019.3076		
Continuation.	1	2063690.2046	2063690.2046	8.3951	0.00522
EW3B	69	16961605.4026	245820.3682		
Order vs quantifier.	6	224479.8622	37413.3104	0.3709	0.89738
EW12B	414	41759759.4949	100868.9843		
Order vs cont.	1	14478.0250	14478.0250	0.1601	0.69283
EW13B	69	6240316.0107	90439.3625		
Quantifier vs cont.	6	745372.1704	124228.6951	1.0942	0.36484
EW23B	414	47003182.4724	113534.2572		
Order vs quantifier vs continuation.	6	367628.0357	61271.3393	0.4980	0.81132
EW123B	414	50939085.1786	123041.2685		

APPENDIX 10(c) continued.

W	1890	232008627.2500

TSQ/N= 3981202137.0250 N= 1960 SST= 260381257.9750